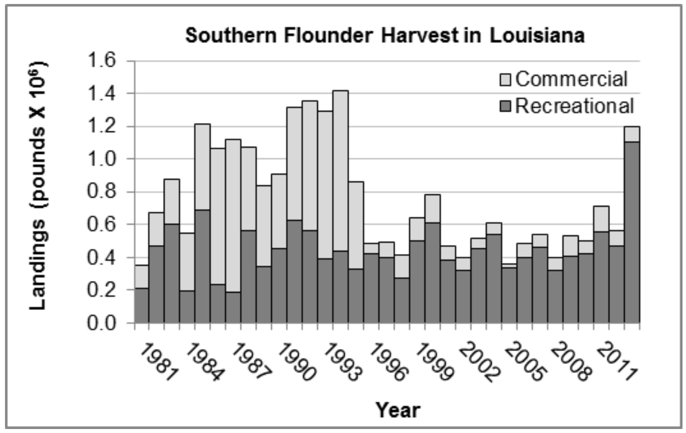
Assessment of Southern Flounder *Paralichthys lethostigma* in Louisiana Waters 2015 Report

Executive Summary

Landings of southern flounder in Louisiana have averaged around 0.6 million pounds per year in the most recent decade. The highest harvests on record (1.3-1.4 million pounds) occurred between 1991-1994. After commercial gear restrictions were enacted in 1995, landings substantially declined (an 84 % decrease from previous years). However, recreational landings in the most recent years have trended upward with the highest estimate of the time-series (1.1 million pounds) occurring in 2013.



A statistical catch at age model is used in this assessment to describe the dynamics of southern flounder occurring in Louisiana waters from 1981-2013. The assessment model forward calculates abundance at age from estimates of abundance in the initial year of the time-series and recruitment estimates in subsequent years. The model is fit to the data with a maximum likelihood fitting criterion. Minimum data requirements are fishery catch-at-age and an index of abundance. Landings are taken from the Louisiana Department of Wildlife and Fisheries Trip Ticket Program, National Marine Fisheries Service commercial statistical records, and the NMFS Marine Recreational Information Program. An index of abundance is developed from the LDWF marine trammel net survey. Age composition of fishery catches are estimated with age-length-keys derived from samples directly of the fishery and a von Bertalanffy growth function.

The conservation threshold established by the Louisiana Legislature for southern flounder is a 30% spawning potential ratio. Based on results of this assessment, the Louisiana southern flounder stock is currently neither overfished or experiencing overfishing. The current spawning potential ratio estimate is 50%.

Summary of Changes from 2010 Assessment

In the prior assessment (Blanchet 2010), an untuned virtual population analysis and yield and spawner-per-recruit models were used to estimate the impact of fishing pressure on potential yield and spawning potential of southern flounder in LA waters. Status of the stock presented in the 2010 report was based on the last four cohorts available for evaluation (1999-2002). In this assessment, a statistical catch at age model is used to estimate annual fishing mortality rates and population size from 1981-2013. Direct comparisons between the earlier and current assessments are not included in this report.

Assessment of Southern Flounder *Paralichthys lethostigma* in Louisiana Waters
2015 Report

Dawn Davis
Joe West
Jason Adriance
Office of Fisheries
Louisiana Department of Wildlife and Fisheries

Joseph E. Powers
School of Coast and Environment
Department of Oceanography and Coastal Sciences
Louisiana State University

Table of Contents

Executive Summary 1
1. Introduction 4
  1.1 Fishery Status 4
  1.2 Fishery Regulations 4
  1.3 Trends in Harvest 5
2. Data Sources 6
  2.1 Fishery Independent 6
  2.2 Fishery Dependent 7
3. Life History Information 8
  3.1 Unit Stock Definition 8
  3.2 Morphometrics 8
  3.3 Growth 8
  3.4 Sex Ratio 9
  3.5 Maturity / Fecundity 9
  3.6 Natural Mortality 9
  3.7 Relative Productivity and Resilience 10
4. Abundance Index Development 11
5. Catch at Age Estimation 12
6. Assessment Model 13
  6.1 Model Configuration 14
  6.2 Model Assumptions/Inputs 17
  6.3 Model Results 17

6.4 Management Benchmarks 19
6.5 Model Diagnostics 20
7. Stock Status 20
8. Research and Data Needs 21
9. References 22
10. Tables 25
11. Figures 43

1. Introduction

A statistical catch-at-age model is used in this assessment to describe the dynamics of southern flounder *Paralichthys lethostigma* (SF) occurring in Louisiana (LA) waters from 1981-2013. The assessment model forward calculates abundance at age from estimates of abundance in the initial year of the time-series and recruitment estimates in subsequent years. The model is fit to the data with a maximum likelihood fitting criterion. Minimum data requirements are fishery catch-at-age and an index of abundance. Landings are taken from the Louisiana Department of Wildlife and Fisheries (LDWF) Trip Ticket Program, National Marine Fisheries Service (NMFS) commercial statistical records, and the NMFS Marine Recreational Fishing Statistical Survey and Marine Recreational Information Program (MRFSS/MRIP). An index of abundance is developed from the LDWF marine inshore trawl survey. Age composition of fishery catches are estimated with age-length-keys derived from samples directly of the fishery (2002-2013) and a von Bertalanffy growth function (1981-2001).

1.1 Fishery Status

A comprehensive history of the SF resource and associated fishery within LA is described in Adkins *et al.* (1998) and for the Gulf of Mexico (GOM) in VanderKooy (2000). A summary of the LA SF fishery is presented below.

Commercial

The LA commercial SF fishery operates primarily within state inside (from the coastline upward to the saltwater line) and outside territorial waters (from the coastline seaward to the state water boundary), with some harvest from federal waters of the Exclusive Economic Zone (EEZ). In the late 1990's, gill net bans combined with other regulation changes caused a decline in commercial SF landings. A majority of commercially harvested SF are landed as incidental catch during shrimp harvest, with a smaller portion of the SF harvest from targeted activity.

Recreational

Similar to the commercial sector, the recreational SF fishery operates primarily within state inside (from the coastline upward to the saltwater line) and outside territorial waters (from the coastline seaward to the state water boundary), with some harvest from federal waters of the EEZ. Southern flounder are not typically the primary target of recreational anglers, but are commonly a second or third preference due to the food quality of their flesh (Adkins *et. al*., 1998).

1.2 Fishery Regulations

The LA southern flounder fishery is governed by the Louisiana State Legislature, the Wildlife and Fisheries Commission, and the LDWF. A review of LA commercial and recreational SF regulations are presented below; full descriptions can be found in Adkins *et al.* (1998) and VanderKooy (2000).

Commercial

Commercial SF harvest regulations changed substantially from 1995 through 1999. Commercial harvest methods were restricted on August 15, 1995, when the Marine Resources Conservation Act of 1995 (Act 1316 of 1995 Regular Legislative Session) became effective. This act prohibited the use of “set” gill nets or trammel nets in saltwater areas of Louisiana, and restricted flounder harvest by "strike" nets to the period between the third Monday in October and March 1 of the following year. A "Restricted Species Permit" issued by LDWF was also required in order to harvest SF with that gear. In 1996, additional regulations became effective that outlawed the use of strike nets for SF harvest and limited the possession limit to 10 fish per person aboard a commercial vessel. In 1997, regulations were changed by Acts 1163 and 1352 of the 1997 Regular Legislative Session in which commercial shrimping vessels were limited to 100 pounds of southern flounder per trip. After March 1, 1997, all flounder harvest by gill or trammel nets was banned. These regulations substantially reduced the harvest of flounder by this segment of the commercial fishing industry. In 1999, regulations were changed by Act 220 of the 1999 Regular Legislative Session that eliminated the 100 pound harvest limit on commercial shrimping when southern flounder were harvested as incidental catch.

Current commercial regulations allow 10 fish for each licensed fisherman for each day on the water except commercial shrimping vessels may retain all SF caught incidentally. There is no size limit on commercially harvested SF.

Recreational

In 1996, recreational regulations were enacted that established a creel limit of ten SF per day per licensed angler, with only one day's limit allowed in possession. On August 15, 2004, regulations were changed by Act 460 of the 2003 Regular Legislative session, which allowed recreational harvest of SF with barbed gigs (prior to 2004 only barbless gigs were allowed). Current recreational regulations allow a 10 fish daily bag and possession limit per licensed angler with no size limit.

1.3 Trends in Harvest

Commercial

Commercial landings of southern flounder in LA have varied greatly since 1950 (Figure 1). Commercial landings peaked from the mid-1980s through the mid-1990s with nearly 1 million pounds landed in 1987 and 1994. From 1986 through 1995, commercial SF harvest exceeded recreational harvest by 63% on average (Table 1). After 1996, commercial landings were substantially reduced mainly due to regulatory changes and have not exceeded 200,000 pounds to date.

The primary gears currently used in the commercial SF fishery are bottom trawls, butterfly nets, skimmer nets, trot lines, hand lines, and traps. In 2013, 91% of commercially landed SF were harvested with butterfly nets, bottom trawls, and skimmer nets (Table 2). The majority of commercial southern flounder landings occurred during the annual offshore migration (October through December; Table 3). Before 2006, commercial landings of SF were relatively evenly distributed among the southeastern portion of the state, offshore, and the western portion of the state (Table 4). After 2005 (the year Hurricanes Katrina and Rita impacted the Louisiana coastline), commercial landings of SF became more concentrated in the southwestern portion of the state and remained so to date.

Recreational

Since 1981, LA recreational SF landings varied between a low of 0.2 million pounds harvested in 1987 to a peak of 1.1 million pounds harvested in 2013 (Table 1, Figure 2). Since 1996, LA recreational SF harvest had exceeded commercial harvest by 82% on average. Recreational landings in recent years had been relatively consistent; however, the 2013 estimate was the highest of the time-series. The majority of recreational harvest occurred during the annual offshore migration (October through December). The most commonly used recreational gears to harvest southern flounder were rod and reel and a barbed gig.

2. Data Sources

2.1 Fishery Independent

The LDWF fishery-independent marine trawl survey is used in this assessment to develop an index of abundance. Below is a brief description of this survey's methodology. Complete details can be found in LDWF (2002).

For sampling purposes, coastal Louisiana is currently divided into five LDWF coastal study areas (CSAs). Current CSA definitions are as follows: CSA 1 – Mississippi State line to South Pass of the Mississippi River (Pontchartrain Basin); CSA 3 – South Pass of the Mississippi River to Bayou Lafourche (Barataria Basin); CSA 5 – Bayou Lafourche to eastern shore of Atchafalaya Bay (Terrebonne Basin); CSA 6 – Atchafalaya Bay to western shore of Vermilion Bay (Vermilion/Teche/Atchafalaya Basins); CSA 7 – western shore of Vermilion Bay to Texas State line (Mermentau/Calcasieu/Sabine Basins). The

LDWF Marine Fisheries Section conducts routine standardized sampling within each CSA as part of a long-term comprehensive monitoring program to collect life-history information and measure relative abundance/size distributions of recreationally and commercially important species. These include the experimental marine gillnet, trawl, trammel net, and beach seine surveys.

In this assessment, only the fishery-independent (FI) marine trawl survey is used. The other FI gears mentioned above are excluded due to very low SF catches. The FI marine trawl survey is conducted with standardized design. Hydrological and climatological measurements are taken with each biological sample, including water temperature, turbidity, conductivity and salinity. Survey gear is a 16 foot flat otter trawl. All captured SF are enumerated and a maximum of 50 randomly selected SF are collected for length measurements.

2.2 Fishery Dependent

Commercial

Commercial SF landings are taken from NMFS commercial statistical records (NMFS 2013a) and the LDWF Trip Ticket Program (Figure 1, Table 1). Commercial live releases are assumed to be insignificant relative to commercial SF harvest and not considered further in this assessment.

It is important to note that NMFS commercial records prior to 2000 did not differentiate landings of flatfish species in Louisiana. Several flatfish species can be found in LA waters, such as the gulf flounder *Paralichthys albigutta*, but the most common species is the southern flounder (VanderKooy 2000). NMFS recreational landings estimates (MRFSS; 1985-1999) indicate gulf flounder comprises only 3% (on average as weight) of the annual recreational harvest relative to SF harvest. Given these small landings, it is unlikely the inclusion of this species in harvest estimates would have a major impact on stock status estimation. Therefore, for purposes of this assessment, commercial landings labeled as flatfish in LA are assumed as southern flounder.

Annual size compositions of commercial SF harvest (Table 5) were developed from samples from the Trip Interview Program (TIPS; 1989-1996) and the Fishery Information Network (FIN; 2002-2013). Due to low length composition samples in early years of the sampling program, a cumulative size composition was developed using the available TIPS data from 1989-1992. This distribution was used as a proxy for 1981-1988 and 1993 where no size composition information was available. During 1997-2001, again, low numbers of southern flounder were sampled from the harvest; therefore, the 2002 size composition was used as a proxy for each of those years. Lastly, for 2011-2012, a cumulative size distribution was developed, again due to low sample size, and used for each of these years.

Ages of commercial southern flounder landings are derived from von Bertalanffy growth functions (1981-2001) and otoliths collected directly from the commercial fishery (2002-2013; see *Catch at Age Estimation*).

Recreational

Recreational southern flounder landings (1981-2013, Type A+B1 only; Table 1 and Figure 2) and corresponding size distributions (Table 6) are taken from MRFSS/MRIP (NMFS 2013b). For 1983 and 1986, only observed harvest (Type A) is used as a landings estimate due to highly inflated and unrealistic Type B1 estimates (~1.5 million fish). Recreational live releases (Type B2 catches) comprise 20% of the total recreational catch from 1981-2013 and are not considered further in this assessment (see *Research and Data Needs*).

Ages of recreational southern flounder landings are derived from von Bertalanffy growth functions (1981-2001) and otoliths collected directly from the recreational fishery (2002-2013; see *Catch at Age Estimation*).

3. Life History Information

3.1 Unit Stock Definition

Genetic studies utilizing allozymes (Blandon et al. 2001) and sequences of mitochondrial DNA (Anderson et al. 2012) suggest SF occurring in the GOM are a distinct stock. However, to remain consistent with the current statewide management strategy, for purposes of this assessment the unit stock is defined as those SF occurring in LA waters.

3.2 Morphometrics

Weight-length regressions for LA SF are reported by Fischer and Thompson (2004). Regression equation slopes comparing males and females are not significantly different. For the purpose of this assessment, the non-sex-specific formulation is used with weight calculated from size as:

$$W = 3.47\times10^{-6}(FL)^{3.21} \quad [1]$$

where W is whole weight in grams and FL is fork length in mm. For southern flounder, total length and fork length are equivalent.

3.3 Growth

Fischer and Thompson (2004) found significant differences between male and female southern flounder growth curves developed from LA-specific data. For the purposes of this assessment, we use their sex-specific von Bertalanffy growth functions with size-at-age calculated from:

$$FL_{a,male} = 332.5 \times 1 - e^{-1.03(a+0.25)}) \quad [2]$$

$$FL_{a,female} = 556.5 \times (1 - e^{-0.51(a+0.62)}) \quad [3]$$

where FL_a is FL-at-age in mm and a is age in years.

3.4 Sex Ratio

Southern flounder exhibit large differences in growth between males and females, with larger flounder being predominantly female (Fischer and Thompson 2004). For purposes of this assessment, an asymptotic function developed in an earlier LDWF southern flounder stock assessment (Blanchet 2005) is employed to estimate the probability of being female at a specific size from:

$$P_{fem,FL} = 1 - e^{(-0.3(FL-4.0))}$$

where FL is in units of inches. The minimum sex ratio-at-size is assumed as 50:50. The probability of being male at a particular FL is taken by difference.

3.5 Maturity / Fecundity

An age-specific maturity vector used in an earlier assessment of southern flounder in Texas (Fisher 2000) is employed in this assessment where no female southern flounder ages-0 to 1 spawn, 50% of age-2 females spawn, and 100% of age-3 females and greater spawn.

Batch fecundity and spawning frequency estimates for SF in LA waters range from 14,046 to 68,829 ova per batch every 3.6 to 6.4 days (Fischer 1999). However, batch fecundity and spawning frequency estimates are currently not available as a function of size, weight, or age (see *Research and Data Needs*). Therefore, for purposes of this assessment, female spawning stock biomass (SSB) is used as a proxy for total egg production. This may introduce bias if fecundity does not scale linearly with body weight (Rothschild and Fogarty 1989).

3.6 Natural Mortality

Southern flounder typically live to at least eight years based on available age samples (Fisher and Thompson 2004; LDWF unpublished data). In the previous assessment (Blanchet 2010), the natural mortality rate is assumed constant across ages; however, an allometric relationship between natural mortality and fish size in natural ecosystems has been demonstrated (Lorenzen 1996). In this assessment, the lowest value of constant M from the previous assessment is assumed for both sexes (M=0.5), but is allowed to vary with weight-at-age to calculate declining sex-specific natural mortality rates with age. The value of M used in this assessment (0.5) is consistent with a stock where approximately 1.5% of the stock remains alive to 8 years of age (Hewitt and Hoenig 2005). Following SEDAR 12 (2006b), the value of M is rescaled for each sex where the average mortality rate over ages vulnerable to the fishery is equivalent to the constant rate over ages as:

$$M_a = M\frac{nL(a)}{\sum_{a_c}^{a_{max}} L(a)} \qquad [4]$$

where M is the constant natural mortality rates over exploitable ages a , a_{max} is the oldest age-class (age-8 in this case), a_c is the first fully-exploited age-class, n is the number of exploitable ages, and $L(a)$ is the Lorenzen curve as a function of age. The Lorenzen curve is calculated from:

$$L(a) = W_a^{-0.288} \qquad [5]$$

where -0.288 is the allometric exponent estimated for natural ecosystems (Lorenzen 1996) and W_a is sex-specific weight-at-age computed from equations [1-3]. The resulting sex-specific M_a vectors are presented in Table 7. For modeling purposes, the sex-specific M_a vectors are averaged by weighting by the annual sex ratio at age. In this case, the sex ratio at age is derived from the annual sex-specific catch at age (see *Catch at Age Estimation*) by assuming sex ratios in the catches are representative of the population (see *Research and Data Needs*).

3.7 Relative Productivity and Resilience

The key parameter in age-structured population dynamics models is the steepness parameter (h) of the stock-recruitment relationship. Steepness is defined as the ratio of recruitment levels when the spawning stock is reduced to 20% of its unexploited level relative to the unexploited level and determines the degree of compensation in the population (Mace and Doonan 1988). Populations with higher steepness values are more resilient to perturbation and if the spawning stock is reduced to levels where recruitment is impaired are more likely to recover sooner once overfishing has ended. Generally, this parameter is difficult to estimate due to a lack of contrast in spawning stock size (*i.e.,* data not available at both high and low levels of stock size) and is typically fixed or constrained during the model fitting process. Estimates of steepness are not available for southern flounder.

Rose et al. (2001) summarizes steepness estimates for periodic, opportunistic, and equilibrium life history strategists for freshwater, pelagic, and anadromous fish stocks from a meta-analysis of Ransom Myers' spawner-recruit datasets (Myers et al.1999). In SEDAR 24-AW-06 (2010), the periodic strategist steepness estimates included in the Rose et al. (2001) meta-analysis are refined to include only marine demersal species (mean and median steepness= 0.77 and 0.80, respectively). For purposes of this assessment, we further refine the list of marine demersal species in SEDAR 24-AW-06 to only include species taxonomically similar (Order Pleuronectiformes; mean and median steepness= 0.83 and 0.86, respectively) and species with similar life history characteristics as discussed below.

Productivity is a function of fecundity, growth rates, natural mortality, age of maturity, and longevity and can be a reasonable proxy for resilience. We characterize the relative productivity of GOM southern flounder based on life-history characteristics, following SEDAR 9 (2006a), with a classification scheme developed at the FAO second technical consultation on the suitability of the CITES criteria for listing commercially-exploited aquatic species (FAO 2001). Each life history characteristic (von Bertalanffy growth rate, age at maturity, longevity, and natural mortality rate) is assigned a rank (low=1, medium=2, and high=3) and then averaged to compute an overall productivity score. In this case, the overall productivity score is 2.75 for GOM southern flounder (Table 8) indicating high productivity. We further refine the list of marine demersal species in SEDAR 24-AW-06 to only include species with similar overall productivity scores (mean and median steepness= 0.79 and 0.81, respectively).

4. Abundance Index Development

An index of abundance (IOA) of age-0 southern flounder was developed from the LDWF FI marine trawl survey for use as a tuning index in ASAP. Older southern flounder were excluded based on size and date of capture using mean lengths at age computed from equations [2 and 3]. Only those CSAs and months with ≥5% positive samples were included in index development. Stations not sampled regularly through time were also excluded. For purposes of this assessment, catch-per-unit effort (CPUE) was defined as the number of age-0 southern flounder caught per trawl tow. To reduce unexplained variability in catch rates unrelated to changes in abundance, the IOA was standardized using methods described below.

A delta lognormal approach (Lo *et al.* 1992; Ingram *et al.* 2010) is used to standardize southern flounder catch-rates in each year (I_y) as:

$$I_y = c_y p_y \quad [6]$$

where c_y are estimated annual mean CPUEs of non-zero southern flounder catches assumed as lognormal distributions, and p_y are estimated annual mean probabilities of southern flounder capture assumed as binomial distributions. The lognormal and binomial means and their standard errors are estimated with generalized linear models as least squares means and back transformed (e^x). The lognormal model considers only samples in which southern flounder are captured; the binomial model considers all samples. The IOA is then computed from equation [6] with variances approximated from a Monte Carlo resampling routine (2000 iterations) using the estimated least-squares means and standard errors.

Variables considered in model inclusion were:

Factor	Levels	Value
Year	33	1981-2013
Month	6	April-September
Area	4	CSA 1,5,6,7
Salinity	Continuous	--
Temperature	Continuous	--

To determine the most appropriate models, factors are selected using a forward step-wise approach where each factor is added to each sub-model individually and the resulting reduction in deviance per degree of freedom (Dev/DF) analyzed. The factor causing the greatest reduction in Dev/DF is then added to the base model. Criteria for model inclusion also include a reduction in Dev/DF ≥1% and a Chi-Square significance test ≤0.05. This procedure is repeated until no factor met criteria for model inclusion. We assume no significant interaction terms with year in this model and consider only the main effects.

The resulting sub-models are as follows:

$$c \sim Year + Month \quad [7]$$

$$p \sim Year + Month + Area \quad [8]$$

Sub-models are estimated with the SAS generalized linear modeling procedure (PROC GENMOD; SAS 1994). Sample sizes, percent positive samples, nominal CPUE, the standardized index of abundance, and coefficients of variation of the standardized index are presented (Table 9).

For modeling purposes, where age-0 catches are not included in the assessment model, the age-0 IOA is used as a proxy of age-1 relative abundance by advancing the time-series forward one year (e.g., 1980 age-0 CPUE becomes 1981 age-1 CPUE; Figure 3).

5. Catch at Age Estimation

Age-length-keys (ALKs) are developed to estimate the annual age composition/catch-at-age of fishery catches as described below.

Southern flounder typically spawn December-January with annulus deposition occurring January-May. Ages of southern flounder in this assessment are assigned based on a January 1st biological birthday, where southern flounder become age-1 on January 1st and remain age-1 until the beginning of the following year.

1981-2001 Sex-specific s probabilities of age a given length l for recreational and commercial SF landings are computed from:

$$P(a|l)_s = \frac{P(l|a)_s}{\sum_a P(l|a)_s} \quad [9]$$

with sex-specific probabilities of length given age estimated from normal probability densities as:

$$P(l|a)_s = \frac{1}{\sigma_a\sqrt{2\pi}}\int_{l-d}^{l+d} exp\left[-\frac{(l-l_{as})^2}{2\sigma_a^2}\right]dl \quad [10]$$

where length bins are 1 inch FL intervals with midpoint l, maximum $l + d$, and minimum $l - d$ lengths. Mean sex-specific fork length-at-age l_{as} is estimated from Equations [2, 3]. The standard deviation in length-at-age is approximated from $\sigma_a = l_a CV_l$, where the coefficient of variation in length-at-age is assumed constant (in this case 0.05 for both sexes). To approximate changes in growth and vulnerability to the fishery through the year, mean l_{as} are calculated at the mid-point of the calendar/model year. The resulting s $P(a|l)_s$ matrices (Table 10) are used in age assignments of 1981-2001 recreational and commercial landings and also for instances discussed below.

2002-2013 Sex-specific probabilities of age given length (2002-2013 landings) are computed for each fishery (f; recreational or commercial) from:

$$P(a|l)_{yfs} = \frac{n_{layfs}}{\sum_a n_{layfs}} \quad [11]$$

where n_{layfs} are annual fishery and sex-specific southern flounder samples occurring in each length/age bin (Tables 11 and 12). For length bins with n <10, the $P(a|l)$ for that length interval is taken from equation [9].

Annual fishery-specific catch-at-age is then taken as:

$$C_{ayf} = \sum_l \sum_s C_{lyfs} P(a|l)_{yfs} \quad [12]$$

where C_{lyfs} are sex-specific annual fishery catch-at-size in FL, and $P(a|l)_{yfs}$ are taken from either equation [9] or [11]. For modeling purposes, catches ≥ age-4 are summed into a plus group. Resulting annual fleet-specific catch-at-age and corresponding mean weights-at-age are presented (Tables 13-16).

6. Assessment Model

The previous LDWF SF stock assessment (Blanchet 2010) estimated the impact of fishing pressure on female SF with an untuned virtual population analysis and yield and spawner-per-recruit analyses. The status of the stock presented in the 2010 report was based on the last four cohorts available for evaluation (1999-2002). In this assessment, a statistical catch-at-age model is used to estimate annual age-specific fishing mortality rates and population size (1981-2013) of SF occurring in LA waters. Direct comparisons between the earlier and current assessments are not included in this report.

The Age-structured Assessment Program (ASAP3; NOAA Fisheries Toolbox, http://nft.nefsc.noaa.gov) is used to describe the dynamics of southern flounder occurring in LA waters. Only the years 1981-2013 are modeled due to the absence of size/age information from earlier years of the fishery. ASAP is a statistical catch-at-age model that allows internal estimation of a Beverton-Holt stock recruitment relationship. Minimum data requirements are fishery catch-at-age, corresponding mean weights-at-age, and an index of abundance. ASAP forward calculates abundance at age from estimates of abundance in the initial year of the time-series and recruitment estimates in subsequent years. The model is fit to the data with a maximum likelihood fitting criterion.

An overview of the basic model equations and their estimation, as applied in this assessment, are provided below. Specific details and full capabilities of ASAP can be found in the technical documentation (ASAP3 2012; NOAA Fisheries Toolbox 2013).

6.1 Model Configuration

Mortality

Fishing mortality is assumed separable by age a, year y, and fishery f as:

$$F_{ayf} = v_{af} Fmult_{yf} \quad [13]$$

where v_{af} are age and fishery-specific selectivities and $Fmult_{yf}$ are fishery-specific apical fishing mortality rates. Apical fishing mortalities are estimated in the initial year and as deviations from the initial estimates in subsequent years.

Age and fishery specific selectivities are modeled with double logistic functions as:

$$v_{af} = \left(\frac{1}{1+e^{-(a-\alpha_f)/\beta_f}}\right)\left(1 - \frac{1}{1+e^{-(a-\alpha 2_f)/\beta 2_f}}\right) \quad [14]$$

Total mortality for each age and year is calculated from the annual age-specific natural mortality rates and estimated annual fleet-specific fishing mortalities as:

$$Z_{ay} = M_{ay} + \sum_f F_{ayf} \quad [15]$$

where M_{ay} are computed by averaging the sex-specific M_a vectors by weighting by the annual sex ratio at age (see *Natural Mortality*).

For reporting purposes, annual fishing mortalities are averaged by weighting by population numbers at age as:

$$F_y = \frac{\sum_a F_{ay} N_{ay}}{\sum_a N_{ay}} \quad [16]$$

Population Abundance

Abundance-at-age in the initial year of the time series and recruitment in subsequent years are estimated and used to forward calculate the remaining numbers at age from the age and year-specific total mortality rates as:

$$N_{ay} = N_{a-1,y-1}e^{-Z_{a-1,y-1}} \quad [17]$$

Numbers in the 4 plus group A are calculated from:

$$N_{Ay} = N_{A-1,y-1}e^{-Z_{A-1,y-1}} + N_{A,y-1}e^{-Z_{A,y-1}} \quad [18]$$

Spawning Stock Biomass

Annual female spawning stock biomass is calculated from:

$$SSB_y = \sum_{i=1}^{A} N_{ay}W_{SSB,a}p_{mat,ay}\, e^{-Z_{ay}(0)} \quad [19]$$

where $W_{SSB,a}$ are female spawning stock biomass weights-at-age (i.e., on January 1st), $p_{mat,ay}$ are the annual proportion of mature females-at-age calculated as the product of the female maturity at age vector and the annual female sex-ratio at age, and $-Z_{ay}(0)$ is the proportion of total mortality occurring prior to spawning on January 1st.

Stock Recruitment

Expected recruitment is calculated from the Beverton-Holt stock recruitment relationship, reparameterized by Mace and Doonan (1988), with annual lognormal deviations as:

$$\hat{R}_{y+1} = \frac{\alpha SSB_y}{\beta + SSB_y} + e^{\delta_{y+1}} \quad [20]$$

$$\alpha = \frac{4\tau(SSB_0/SPR_0)}{5\tau-1} \text{ and } \beta = \frac{SSB_0(1-\tau)}{5\tau-1}$$

where SSB_0 is unexploited female spawning stock biomass, SPR_0 is unexploited female spawning stock biomass per recruit, τ is steepness, and $e^{\delta_{y+1}}$ are annual lognormal recruitment deviations.

Expected Catch

Expected fishery catches by age, fishery, and year are estimated from the Baranov catch equation as:

$$\hat{C}_{ayf} = N_{ay}F_{ayf}\frac{(1-e^{-Z_{ay}})}{Z_{ay}} \quad [21]$$

Expected fishery age compositions are then calculated from $\frac{\hat{\hat{C}}_{ayf}}{\sum_a \hat{C}_{ayf}}$. Expected yields are computed as $\sum_a \hat{C}_{ayf}\bar{W}_{ayf}$, where $\bar{W}_{ayf}$ are observed fishery-specific mean catch weights.

Survey Catch-rates

Expected annual survey catch-rates of age-1 southern flounder are computed from:

$$\hat{I}_{a=1,y} = qN_{a=1,y}(1 - e^{-Z_{a=1,y}(0.5)}) \quad [22]$$

where q is the estimated catchability coefficient, and $-Z_{a=1,y}(0.5)$ is the proportion of the total mortality occurring on age-1 individuals prior to the time of the survey (July 1st midpoint).

Parameter Estimation

The number of parameters estimated is dependent on the length of the time-series, number of fleets and selectivity blocks modeled, and number of tuning indices modeled. Parameters are estimated in log-space and then back transformed. In this assessment, 116 parameters are estimated:

1. 12 selectivity parameters (4 parameters per selectivity block: 2 blocks for the commercial fishery and 1 block for the recreational fishery,)
2. 66 apical fishing mortality rates (F_{mult} in the initial year and 32 deviations in subsequent years for 2 fleets)
3. 33 recruitment deviations (1981-2013)
4. 3 initial population abundance deviations (age-2 through 4-plus)
5. 1 survey catchability coefficient
6. 1 stock-recruitment parameter (unexploited SSB)

The model is fit to the data by minimizing the objective function:

$$-ln(L) = \sum_i \lambda_i(-ln\, L_i) + \sum_j(-ln\, L_j) \quad [23]$$

where $-ln(L)$ is the entire negative log-likelihood , lnL_i are log-likelihoods of lognormal estimations, λ_i are user-defined weights applied to lognormal estimations, and lnL_j are log-likelihoods of multinomial estimations.

Negative log-likelihoods with assumed lognormal error are derived (ignoring constants) as:

$$-ln(L_i) = 0.5 \sum_i \frac{[ln(obs_i) - ln(pred_i)]^2}{\sigma^2} \quad [24]$$

where obs_i and $pred_i$ are observed and predicted values; standard deviations σ are user-defined CVs as $\sqrt{ln(CV^2+1)}$.

Negative log-likelihoods with assumed multinomial error are derived (ignoring constants) as:

$$-ln\left(L_j\right) = -ESS \sum_{i=1}^{A} p_i\, ln(\hat{p}_i) \quad [25]$$

where p_i and $\hat{p}_i$ are observed and predicted age compositions. Effective sample-sizes ESS act as multinomial weighting factors.

6.2 Model Assumptions/Inputs

Model assumptions include: 1) the unit stock is adequately defined and closed to migration, 2) observations are unbiased, 3) errors are independent and their structures are adequately specified, 4) fishery vulnerabilities are dome-shaped, 5) abundance indices are proportional to absolute abundance, and 6) natural mortality, fecundity, growth and sex ratio at size do not vary significantly with time. Lognormal error is assumed for catches, abundance indices, the stock-recruitment relationship, apical fishing mortality, selectivity parameters, initial abundance deviations, and catchability. Multinomial error is assumed for fishery and survey age compositions.

A base model was defined with an age-4 plus group, the steepness parameter fixed at 0.85, two commercial fishery selectivity blocks, one recreational selectivity block, and input levels of error and weighting factors as described below.

For the commercial fleet, two selectivity blocks are modeled that correspond to the following time-periods of consistent regulation: 1) 1981-1995 (no regulations), 2) 1996-2013 (commercial gill and trammel nets banned). Within the recreational fleet, only one selectivity block is modeled due to no major regulation changes over the time-period modeled

Input levels of error for fishery landings were specified with CV's of 0.1 for the commercial fleet and 0.2 for the recreational fleet and IOA for each year of the time-series; annual recruitment deviations were specified with CV's of 0.5. All lambdas for lognormal components included in the objective function were equally weighted (=1). Input effective sample sizes for estimation of fishery age compositions were specified as ESS=50 for years where annual ALKs were available (2002-2013) and down weighted to ESS=10 for years where von Bertalanffy growth functions were used (1981-2001).

6.3 Model Results

Objective function components, weighting factors, and likelihood values of the base model are summarized in Table 17.

Model Fit

The base model provides an overall reasonable fit to the data. Predicted commercial and recreational catches match the observations well (Figures 4 and 5). However, patterning of the residuals is apparent where each fisheries landings are generally underestimated in earlier years of the time-series. For the recreational fishery, the landings also tend to be overestimated in the more recent years. Predicted survey catch-rates provide reasonable fits to the data with no patterning observed in the residuals (Figure 6). Predicted fishery age compositions provide reasonable fits to the input age proportions (Figures 7-8).

Selectivities

Estimated fishery and survey selectivities are presented in Figure 9. Fishery estimates indicate full-vulnerability to the commercial fishery at age-1 during the 1981-1995 and 1996-2013 regulation blocks. Recreational estimates also indicate full-vulnerability to the fishery at age-1.

Abundance, Spawning Stock, and Recruitment

Stock size has varied over the time-series (Table 18). Stock size decreased from 3.8 million fish in 1983 to a minimum of 1.4 million fish in 2001. Stock size remained relatively steady from 2006-2013 (mean of 2.2 million fish). The 2013 stock size estimate of 1.9 million fish is near the long-term mean of 2.4 million fish.

Female SSB decreased slightly from 1983 to 1987 with a leveling off in the most recent years (Figure 10). Estimates decreased from a maximum of 2.4 million pounds in 1983 to a minimum of 0.7 pounds in 1987. From 1990 to 2013, female SSB averaged 1.5 million pounds, which is slightly higher than the 2013 estimate of 1.1 million pounds. The low estimate of female SSB in 2002 was preceded by a series of years with low recruitment levels.

Recruitment has also varied over the time-series (Figure 11). Recruitment decreased from a maximum of 2.4 million age-1 fish in 1983 to a low of 0.7 million individuals in 2001. Post-2001, recruitment increased to 2.0 million flounder in 2004 followed by a substantial decrease in 2005 to 0.7 million age-1 fish. The 2013 recruitment estimate of 0.9 million age-1 fish is less than the long-term mean of 1.4 million age-1 fish.

Fishing Mortality

Estimated fishing mortality rates are presented in Table 19 (total apical, average, and age-specific) and Figure 12 (average only). Average F rates are weighted by population numbers at age. Average fishing mortality rates have varied over the time-series. The lowest and highest estimates of average F are in earlier years of the time series with a minimum of 0.13 year^{-1} estimated in 1981 and a maximum of 0.67 year^{-1} estimated in 1993. The long-term mean of average F is 0.34 year^{-1}. The 2013 estimate is the second highest of the time-series at 0.64 year^{-1}.

Stock-Recruitment

No discernable relationship is observed between female SSB and subsequent age-1 recruitment (Figure 13). In the base model run, unexploited SSB was estimated as 2.6 million pounds with the steepness parameter fixed at 0.85. When allowed to directly solve for steepness, the parameter was estimated as

1.0. Alternate model runs with steepness values fixed at 1.0, 0.9, 0.8, and 0.7 are discussed in the *Model Diagnostics* Section below.

Parameter Uncertainty

In the ASAP base model, 116 parameters were estimated. Asymptotic standard errors for the recruitment time-series are presented in Figure 11. Markov Chain Monte Carlo (MCMC) derived 95% confidence intervals (CI) for the median female SSB and average F rates are presented in Figures 10 and 12. Uncertainty around average F has remained fairly constant across the time series, whereas uncertainty around female SSB has decreased since the early 1980's.

6.4 Management Benchmarks

The conservation standard established by the LA Legislature for southern flounder (RS 56:325.4: http://www.legis.la.gov/Legis/Law.aspx?d=105210) is a 30% spawning potential ratio (SPR; Goodyear 1993). Methodology used in this assessment to estimate equilibrium yield, female SSB, and average F rates that lead to a 30% SPR are described below.

When the stock is in equilibrium, equation [19] can be solved, excluding the year index, for any given exploitation rate as:

$$\frac{SSB}{R}(F) = \sum_{i=1}^{A} N_a W_{SSB,a} p_{mat,a}\, e^{-Z_a(0.0)} \text{ [26]}$$

where total mortality at age Z_a is computed as $M_a + v_a Fmult$; fishery vulnerability at age v_a is calculated by rescaling the current F-at-age estimate (geometric mean 2011-2013) to the maxim. Natural mortality at age M_a is taken as the 2011-2013 geometric mean of M_{ay}; the proportion of mature females at age $p_{mat,a}$ is taken as the 2011-2013 arithmetic mean of $p_{mat,ay}$. Per recruit abundance-at-age is estimated as $N_a = S_a$, where survivorship at age is calculated recursively from $S_a = S_{a-1}e^{-Z_a}$, $S_1 = 1$. Per recruit catch-at-age is calculated with the Baranov catch equation [21], excluding the year index. Yield per recruit (Y/R) is then taken as $\sum_a C_a \bar{W}_a$ where $\bar{W}_a$ are current mean fishery weights at age (arithmetic mean 2011-2013). Fishing mortality is averaged by weighting by relative numbers at age. Equilibrium spawning stock biomass $\mathrm{SSB_{eq}}$ is calculated by substituting SSB/R estimated from equation [26] into the Beverton-Holt stock recruitment relationship as $\alpha \times SSB/R - \beta$. Equilibrium recruitment R_{eq} and yield Y_{eq} are then taken as $SSB_{eq} \div SSB/R$ and $Y/R \times R_{eq}$. Equilibrium SPR is then computed as the ratio of SSB/R when F>0 to SSB/R when F=0.

As reference points to guide management, we estimate the equilibrium average F rate, female SSB, and yield that lead to 30% SPR ($SSB_{30\%}$, $F_{30\%}$, and $Y_{30\%}$; Table 20). Also presented are a plot of the stock recruitment data, equilibrium recruitment, and diagonals from the origin intersecting R_{eq} at the minimum and maximum SSB estimates of the time-series, corresponding with a minimum equilibrium SPR of 26% and a maximum of 80% (Figure 14). The current estimate of SPR is 50%.

6.5 Model Diagnostics

Sensitivity Analysis

A series of sensitivity runs are used to explore uncertainty in the base model's configuration as follows:

1. steepness parameter h fixed at 1.0, 0.9 , 0.8, and 0.7(models 1-4)
2. fishery landings up-weighted ($\lambda \times$ 8; model 5)
3. survey catch-rates up-weighted ($\lambda \times$ 8; model 6)
4. commercial fishery down-weighted ($\lambda \times$ 0.2; model 7)

Current conditions are taken as the geometric mean (SSB and average F) of the last three years of the assessment (2011-2013). Reference point estimates from all of the sensitivity runs indicate the stock is currently above $SSB_{30\%}$ and the fishery is currently operating below $F_{30\%}$ (Table 21). Estimates of $F_{30\%}$, $SSB_{30\%}$, and $Y_{30\%}$ from all sensitivity runs are similar in magnitude (0.59-0.60 year^{-1}, 0.8-0.9 million pounds, and 0.8-0.9 million pounds, respectively).

Retrospective Analysis

A retrospective analysis is conducted by sequentially truncating the base model by a year (terminal years 2009-2013 only). Retrospective estimates of recruitment, $SSB/SSB_{30\%}$, and $F/F_{30\%}$ are presented in Figure 15, where $SSB_{30\%}$ and $F_{30\%}$ are computed from the base model run. Estimated terminal year $SSB/SSB_{30\%}$, $F/F_{30\%}$, and age-1 recruits are similar to the base model run indicating little retrospective bias.

7. Stock Status

The history of the LA southern flounder stock relative to $F/F_{30\%}$ and $SSB/SSB_{30\%}$ is presented in Figure 16. Given the established conservation standard of 30% SPR, fishing mortality rates exceeding $F_{30\%}$ ($F/F_{30\%} > 1.0$) are defined as overfishing; spawning stock sizes below $SSB_{30\%}$ ($SSB/SSB_{30\%} < 1.0$) are defined as the overfished condition. Current conditions (i.e., female SSB and average F) are derived as geometric means from the last three years of the ASAP base model run (2011-2013).

Overfishing Status

Using results of the ASAP model presented in this assessment, the 2011-2013 estimate of $F/F_{30\%}$ is 0.64, suggesting the stock is currently not undergoing overfishing. However, the current assessment model indicates that the stock did experience overfishing in 1993, 1994, and 2013.

Overfished Status

The 2011-2013 estimate of $SSB/SSB_{30\%}$ is 1.76, suggesting the stock is currently not in an overfished state. The current assessment model indicates that the stock was considered overfished in 1987.

Control Rules

As specified in RS 56:325.4 , if the most current LDWF southern flounder stock assessment indicates current SPR < 30%, the department shall close the season within two weeks for a period of at least one year, or shall provide, for the commissions consideration, management options derived from data that indicate that the spawning potential ratio is estimated to have at least a fifty percent chance of recovery to a thirty percent ratio within ten years or some other appropriate recovery period based on the biology of the stock of the fish, environmental conditions, and the needs of the fishing communities..

8. Research and Data Needs

As with any analysis, the accuracy of this assessment is dependent on the accuracy of the information of which it is based. Below we list recommendations to improve future stock assessments of southern flounder, not in any order of priority.

Only limited catches of southern flounder occur in LDWF FI surveys. Expanding the LDWF FI surveys to a gear more effective in capturing adult southern flounder would allow an additional tuning index in future modeling efforts that could help better characterize spawning stock size. Also, there are only limited age data available from the LDWF surveys. Age samples collected directly from the surveys in question would allow a more accurate representation of survey age composition in future assessments and provide auxiliary life-history information, such as sex-ratios at age of the population.

The Southeast Area Monitoring and Assessment Program (SEAMAP) conducts fishery-independent monitoring surveys in the GOM. The summer and fall shrimp/groundfish surveys, in particular, may provide useful information on adult southern flounder abundance in nearshore waters. Future efforts should explore these datasets and assess their potential for future use in southern flounder stock assessments.

Stock losses due to discard mortality are not taken into account in this stock assessment. If data characterizing the size/age composition of recreational releases becomes available, future stock assessment efforts could account for this source of mortality.

Estimates of southern flounder batch fecundity and spawning frequency as a function of age/size are needed.

Fishery-dependent data alone is not a reliable source of information to assess status of a fish stock. Consistent fishery-dependent and fishery-independent data sources, in a comprehensive monitoring plan, are essential to understanding the status of fishery. A new LDWF fishery-independent survey methodology was implemented in 2013. This methodology should be assessed for adequacy with respect to its ability to evaluate stock status, and modified if deemed necessary.

Factors that influence year-class strength of southern flounder are poorly understood. Investigation of these factors could elucidate causes of inter-annual variation in abundance, as well as the species stock-recruitment relationship.

With the recent trend toward ecosystem-based assessment models (Mace 2000; NMFS 2001), more data is needed linking southern flounder population dynamics to environmental conditions. The addition of meteorological and physical oceanographic data coupled with food web data may lead to a better understanding of the southern flounder stock and its habitat.

9. References

Adkins, G., S. Hein, P. Meier, and B. McManus. 1998. A biological and fisheries profile for southern flounder, *Paralichthys lethostigma* in Louisiana. Louisiana Department of Wildlife and Fisheries, Office of Fisheries, Fishery Management Plan Series No. 6, Part 1.

Anderson, J.D., W.J. Karel, and A.C.S. Mione. 2012. Population Structure and Evolutionary History of Southern Flounder in the Gulf of Mexico and Western Atlantic Ocean. *Transactions of the American Fisheries Society*. 141(1): 46-55.

Blanchet, H. 2005. Southern flounder- Summary of changes from 2004 assessment– 2005 report. Report to the Louisiana Legislature by the Wildlife and Fisheries Commission. February 2005. 27 pp.

Blanchet, H. 2010. Assessment of southern flounder in Louisiana waters – 2010 report. Report to the Louisiana Legislature by the Wildlife and Fisheries Commission. February 2010. 27 pp.

Blandon IR, R.Ward, T.L. King, W.J. Karel, and J.P. Monaghan. 2001. Preliminary genetic population structure of southern flounder, *Paralichthys lethostigma*, along the Atlantic coast and Gulf of Mexico. U.S. National Marine Fisheries Service Fishery Bulletin 99:671-678

FAO. 2001. Second Technical Consultation on the Suitability of the CITES Criteria for Listing Commercially-exploited Aquatic Species: A background analysis and framework for evaluating the status of commercially-exploited aquatic species in a CITES context. Available: http://www.fao.org/docrep/MEETING/003/Y1455E.htm

Fischer, A. 1999. The life history of southern flounder (Paralichthys lethostigma) in Louisiana waters. M.S. Thesis, Louisiana State University, Baton Rouge, Louisiana. 68 p.

Fischer, A. and B. Thompson. 2004. The age and growth of southern flounder, *Paralichthys lethostigma*, from Louisiana estuarine and offshore waters. *Bulletin of Marine Science*. 75(1):63-77.

Fisher, M.R. 2000. Assessment of western Gulf stocks- Stock assessment of southern flounder (*Paralichthys lethostigma*) in Texas waters. I*n* the Flounder Fishery of the Gulf of Mexico, United States: A Regional Management Plan. Ed. S.J. VanderKooy. Gulf States Marine Fisheries Commission. No. 83. 323 pp.

Goodyear, C.P. 1993. Spawning stock biomass per recruit in fisheries management: foundation and current use. *pp* 67-81 *in* S.J. Smith, J.J. Hunt and D. Rivard [ed.]. Risk evaluation and biological reference points for fisheries management. *Canadian Special Publication of Fisheries and Aquatic Sciences*. 442 pp.

Hewitt, D.A., and J. M. Hoenig. 2005. Comparison of two approaches for estimating natural mortality based on longevity. *Fisheries Bulletin*. 103:433–437.

Ingram, G.W., Jr., W.J. Richards, J.T. Lamkin, and B. Muhling. 2010. Annual indices of Atlantic bluefin tuna (*Thunnus thynnus*) larvae in the Gulf of Mexico developed using delta-lognormal and multivariate models*. Aquat. Living Resour.* 23:35–47.

LDWF. 2002. Marine Fisheries Division Field Procedures Manual. Louisiana Department of Wildlife and Fisheries, Version 02-1, Baton Rouge, LA.

Lo, N.C.H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Canadian Journal of Fisheries and Aquatic Science*. 49:2515–2526.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. *Journal of Fish Biology* 49:627-642.

Mace, P.M., and I.J. Doonan. 1988. A generalized bioeconomic simulation model for fish population dynamics. Technical Report 88, New Zealand Fisheries Assessment Resource Document.

Mace, P.M. [ed.]. 2000. Incorporating ecosystem considerations into stock assessments and management advice. Proceedings of the 6th NMFS National Stock Assessment Workshop (NSAW). NOAA Technical Memorandum NMFS-F/SPO-46. 78 pp.

Myers, R., K.G. Bowen, and N.J. Barrowman. 1999. Maximum reproductive rate of fish at low population sizes. Can. J. Fish. Aquat. Sci. 56: 2404–2419. http://www.mscs.dal.ca/~myers/welcome.html

NMFS. 2001. Marine Fisheries Stock Assessment Improvement Plan. Report of the National Marine Fisheries Service National Task Force for Improving Fish Stock Assessments. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-56, 69 p., 25 appendices.

NMFS. 2013a. Annual commercial landings statistics. National Marine Fisheries Service, Fisheries Statistics and Economics Division. Available: http://www.st.nmfs.noaa.gov/commercial-fisheries/index [accessed 4/2014].

NMFS. 2013b. Marine recreational fisheries statistical survey. National Marine Fisheries Service, Fisheries Statistics and Economics Division. Available: http://www.st.nmfs.noaa.gov/recreational-fisheries/index [accessed 4/2014].

NOAA Fisheries Toolbox. 2013. Age Structured Assessment Program (ASAP), Version 3.0.14. Available: www.nft.nefsc.noaa.gov .

Rose, K., J.H. Cowan Jr, K.O. Winemiller, R.A. Myers, and R. Hilborn. 2001. Compensatory density dependence in fish populations: importance, controversy, understanding and prognosis. *Fish and Fisheries*. 2:293–327.

Rothschild, B.J., and M.J. Fogarty. 1989. Spawning-stock biomass: a source of error in recruitment/stock relationships and management advice. *ICES Journal of Marine Science.* 45:131-135.

SAS Institute. 1994. SAS/STAT version 9.1 user's guide. SAS Institute, Cary, North Carolina.

SEDAR. 2006a. Gulf of Mexico Vermilion Snapper SEDAR 9 Assessment Report 3. SEDAR, Charleston, SC. Available at http://www.sefsc.noaa.gov/sedar/

SEDAR, 2006b. Stock Assessment of Gulf of Mexico Red Grouper. SEDAR 12, Charleston, SC. Available at http://www.sefsc.noaa.gov/sedar/

SEDAR, 2010. SEDAR24-AW06 Spawner-recruit relationships of demersal marine fishes: Prior distribution of steepness for possible use in SEDAR stock assessments. SEDAR, Charleston, SC. Available at http://www.sefsc.noaa.gov/sedar/

VanderKooy, S.J. 2000. The Flounder Fishery of the Gulf of Mexico, United States: A Regional Management Plan. Gulf States Marine Fisheries Commission. Ocean Springs, MS.

10. Tables

Table 1: Louisiana annual commercial and recreational southern flounder landings (pounds x 10^3) derived from NOAA-Fisheries commercial statistical records, LDWF trip ticket program, and MRFSS/MRIP. Recreational landings are type A+B1 catches only, except for 1983 and 1986; where landings are type A catches only (see text for details).

Year	Harvest		%_Commercial	%_Recreational
	Commercial	Recreational		
1981	137	213	39.1	60.9
1982	200	472	29.7	70.3
1983	276	599	31.6	68.4
1984	353	195	64.5	35.5
1985	530	686	43.6	56.4
1986	825	237	77.7	22.3
1987	938	184	83.6	16.4
1988	510	565	47.5	52.5
1989	492	346	58.7	41.3
1990	456	452	50.2	49.8
1991	692	622	52.7	47.3
1992	785	566	58.1	41.9
1993	899	393	69.6	30.4
1994	975	441	68.8	31.2
1995	533	329	61.9	38.1
1996	62	422	12.8	87.2
1997	95	399	19.2	80.8
1998	140	271	34.0	66.0
1999	141	498	22.0	78.0
2000	177	606	22.6	77.4
2001	90	381	19.2	80.8
2002	82	318	20.4	79.6
2003	64	454	12.3	87.7
2004	74	536	12.1	87.9
2005	22	338	6.0	94.0
2006	84	398	17.4	82.6
2007	79	463	14.6	85.4
2008	77	324	19.3	80.7
2009	131	404	24.5	75.5
2010	81	420	16.2	83.8
2011	154	558	21.7	78.3
2012	97	468	17.2	82.8
2013	89	1,106	7.5	92.5

Table 2: Percent contribution by gear of Louisiana commercial southern flounder landings from the LDWF Trip Ticket Program, 2000-2013.

% Commercial Landings by Gear						
YEAR	BUTTERFLY NETS	OTTER TRAWL, SHRIMP	SKIMMER NETS	TROT LINES	POTS & TRAPS, CRAB	OTHER
2000	21.1	35.7	7.8	9.7	2.6	14.3
2001	4.4	49.1	17.9	4.5	1.2	14.3
2002	8.2	59.3	21.8	3.9	2.5	4.1
2003	19.7	55.5	13.5	6.7	2.3	2.3
2004	37.2	36.0	15.8	5.4	3.1	2.4
2005		54.3	12.2	15.7	6.4	11.2
2006	49.7	24.9	10.7	5.2	4.9	4.6
2007	31.4	20.4	32.7	8.3	6.8	0.4
2008	43.8	27.6	17.2	7.7	2.9	0.9
2009	26.6	40.5	11.3	11.9	4.4	5.3
2010	62.4	18.0	6.6	6.2	4.0	2.8
2011	54.5	11.1	15.0	10.7	2.9	5.8
2012	62.5	12.3	11.0	9.7	2.8	1.7
2013	62.3	10.7	18.3	5.9	1.7	1.1

Table 3: Percent contribution by month of Louisiana commercial southern flounder landings from the LDWF Trip Ticket Program, 2000-2013.

	% Commercial Landings by Month											
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	2.8	1.8	3.5	3.6	2.9	3.0	1.8	3.0	6.8	18.8	45.1	6.8
2001	4.6	4.9	5.3	2.6	1.4	3.6	1.8	2.0	4.3	21.0	31.8	16.7
2002	1.7	1.0	1.0	0.6	1.4	1.7	2.1	1.9	4.7	7.8	52.6	23.6
2003	11.9	0.3	0.8	0.7	0.7	1.1	1.1	1.5	3.6	7.1	59.3	11.8
2004	1.5	0.6	0.3	0.9	0.8	3.3	3.9	0.7	5.6	4.9	54.6	22.8
2005	6.6	3.0	2.4	0.9	2.7	4.7	5.2	8.4	6.3	2.1	41.5	16.2
2006	0.5		0.2	0.3	0.7	0.3	0.9	0.6	3.5	24.3	59.7	9.2
2007	0.2	0.1	0.2	0.4	0.8	0.6	0.5	1.1	0.9	39.7	50.4	5.1
2008	1.8	2.5	0.3	0.4	0.5	1.3	2.0	2.3	2.1	13.0	59.9	13.9
2009	0.8	1.4	0.3	0.0	0.8	2.9	0.9	3.5	2.8	25.4	50.8	10.3
2010	2.0	2.3	0.5	1.1	0.9	1.0	0.9	0.4	0.7	27.5	53.1	9.6
2011		0.7	0.4	0.6	0.8	1.0	1.0	1.3	2.4	26.6	60.9	4.2
2012	0.1	0.7	0.1	0.7	0.4	1.0	0.8	4.6	0.4	33.8	48.9	8.5
2013	0.1	0.9	0.3	0.3	0.4	0.5	0.4	1.0	1.1	9.2	81.3	4.6

Table 4: Percent contribution by area of Louisiana commercial southern flounder landings from the LDWF Trip Ticket Program, 2000-2013.

	% Commercial Landings by Area													
Area/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ATCHAFALAYA/VERMILION-TECH	9.6	3.2	5.1	0.5	2.7	13.7	1.3	2.7	2.7	2.4	1.5	3.6	3.9	3.3
BARATARIA	17.6	16.4	26.8	15.4	12.5	15.9	8.7	14.8	12.5	7.9	3.3	3.8	2.8	5.2
CALCASIEU RIVER	35.9	23.3	15.0	25.4	44.5	41.4	76.3	49.1	63.9	76.2	86.7	68.3	84.9	83.9
LAKE PONTCHARTRAIN	2.5	11.1	14.6	13.4	5.9	5.4	4.9	23.0	16.0	9.3	6.0	17.3	6.0	5.2
LOUISIANA GRID 13	12.4	17.4	18.9	21.0	20.1	20.0	5.0	4.4				4.7		
LOUISIANA GRID 14	0.9	6.0	2.7	2.4	2.1	1.1		0.1						
LOUISIANA GRID 15	0.1		0.6	0.1										
LOUISIANA GRID 16	0.2		0.0											
LOUISIANA GRID 17	11.3			12.0	7.2									
MERMENTAU RIVER	0.8	0.9			0.7			2.9					0.2	
MISSISSIPPI COAST	0.1													
MISSISSIPPI RIVER	7.8	21.0	8.8	8.1	4.1	1.3	2.2	2.4	2.9	2.4	1.5	0.5	0.7	1.3
TERREBONNE	0.5	0.8	7.4	1.8	0.2	1.1	1.6	0.5	2.1	1.8	1.2	1.8	1.4	1.1
UNKNOWN AREAFISHED	0.4													

Table 5: Annual size composition samples of Louisiana commercial southern flounder landings derived from the Trip Interview Program (TIPS; 1981-1992) and the Fishery Information Network (FIN; 2002-2013). Cumulative size distributions are presented for years where only limited size composition data were available. FL_in is fork length in inches.

	Commercial, 1981-2013													
FL_in	1981-1993	1994	1995	1996	1997-2002	2003	2004	2005	2006	2007	2008	2009	2010	2011-2012	2013
7							1	1				2			
8					1	2	6		2			5			
9	1	6	3		15	10	41	2	17	16		12	16	8	1
10	1	2	13	1	37	26	75	5	25	24	1	27	35	5	
11	1	17	43	5	76	63	76	4	25	12	5	77	120	15	
12	12	26	42	7	55	65	45	31	32	17	31	20	55	28	1
13	47	67	106	10	40	43	43	74	64	35	39	3	8	21	5
14	33	97	196	22	44	80	59	35	74	45	42	7	17	7	13
15	24	132	222	18	39	56	49	24	56	65	37	11	3	12	40
16	14	98	138	10	35	32	30	10	47	39	26	16	1	10	19
17	8	66	74	9	32	32	11	21	29	30	5	12	1	10	19
18	3	49	35	5	53	11	6	6	12	14		10	1	3	4
19	3	37	19	1	63	1	2	1	15	5		13			5
20		17	21	1	25	3	1	3	12	2		9			2
21		9	8	2	5		1	1	3			4			
22	2	9	2		2	2			1	2		2			1
23	2	6			7	1						1			
24	2	1	1		1										
25		2													
26		1													
27															
Totals	153	642	923	91	530	427	446	218	414	306	186	231	257	119	110

Table 6: Annual size distributions of Louisiana recreational southern flounder harvest taken from MRFSS/MRIP. FL_in is fork length in inches.

	Recreational, 1981-2013																
FL_in	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
5		0.00						0.00			0.01						
6		0.01	0.00														
7		0.03	0.01			0.00	0.01			0.01			0.00	0.00	0.02		
8	0.04	0.11	0.01	0.03		0.01		0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.00	0.01
9	0.06	0.14	0.01	0.00	0.03	0.02	0.02	0.02	0.00	0.04	0.03	0.04	0.03	0.02	0.05	0.02	0.04
10	0.07	0.06	0.02	0.02	0.06	0.08	0.10	0.02	0.07	0.11	0.07	0.06	0.06	0.05	0.14	0.05	0.06
11	0.07	0.13	0.05	0.04	0.03	0.17	0.17	0.10	0.13	0.19	0.12	0.10	0.11	0.06	0.10	0.09	0.08
12	0.20	0.15	0.02	0.28	0.11	0.23	0.25	0.11	0.07	0.11	0.16	0.14	0.16	0.14	0.17	0.19	0.16
13	0.15	0.08	0.18	0.07	0.17	0.09	0.09	0.15	0.11	0.10	0.17	0.11	0.13	0.23	0.10	0.16	0.16
14	0.09	0.06	0.01	0.22	0.20	0.22	0.12	0.17	0.20	0.12	0.18	0.14	0.13	0.16	0.07	0.15	0.20
15	0.18	0.09	0.34	0.17	0.26	0.08	0.09	0.14	0.16	0.16	0.12	0.18	0.11	0.12	0.13	0.14	0.08
16	0.09	0.06	0.17	0.08	0.02	0.06	0.07	0.11	0.10	0.07	0.06	0.10	0.12	0.09	0.10	0.07	0.09
17		0.01	0.01		0.07	0.02	0.04	0.05	0.09	0.05	0.04	0.05	0.09	0.06	0.04	0.05	0.07
18		0.04	0.18	0.08	0.02	0.01	0.03	0.04	0.04	0.02	0.01	0.05	0.05	0.03	0.04	0.04	0.02
19		0.01		0.01	0.01	0.00	0.01	0.04	0.02		0.02	0.02	0.01	0.00	0.02	0.03	0.02
20	0.02	0.01			0.01	0.00		0.04		0.01	0.01	0.01		0.01		0.01	0.00
21		0.02			0.01	0.00		0.00	0.01	0.01	0.01	0.01		0.00	0.00	0.01	0.01
22		0.00			0.00	0.00						0.00	0.00	0.00			
23									0.00					0.00	0.00		
24																	0.00
25																	
26																	
27											0.00						

FL_in	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
5		0.00														
6																
7		0.00				0.00									0.00	
8			0.01	0.01	0.02	0.01	0.01			0.01	0.01	0.02	0.00	0.01	0.01	0.00
9	0.02		0.00		0.04	0.03	0.04	0.00		0.01	0.04	0.01	0.00	0.03	0.01	0.01
10	0.06	0.04	0.04	0.02	0.14	0.07	0.10	0.02	0.03	0.03	0.03	0.04	0.04	0.08	0.07	0.02
11	0.12	0.09	0.04	0.05	0.10	0.09	0.10	0.16	0.07	0.17	0.07	0.05	0.08	0.09	0.07	0.05
12	0.18	0.14	0.15	0.10	0.11	0.16	0.15	0.18	0.17	0.14	0.19	0.14	0.16	0.11	0.10	0.07
13	0.20	0.20	0.13	0.12	0.10	0.22	0.17	0.16	0.17	0.13	0.14	0.16	0.17	0.15	0.23	0.09
14	0.17	0.16	0.16	0.22	0.15	0.16	0.17	0.21	0.17	0.18	0.17	0.16	0.20	0.15	0.11	0.19
15	0.11	0.14	0.18	0.16	0.17	0.11	0.12	0.11	0.14	0.14	0.14	0.14	0.16	0.13	0.11	0.22
16	0.05	0.10	0.09	0.12	0.10	0.09	0.08	0.10	0.13	0.06	0.06	0.14	0.07	0.12	0.11	0.20
17	0.05	0.06	0.11	0.09	0.04	0.02	0.03	0.04	0.05	0.07	0.07	0.06	0.05	0.09	0.09	0.08
18	0.02	0.04	0.04	0.06	0.01	0.02	0.01	0.01	0.02	0.03	0.05	0.02	0.04	0.02	0.05	0.05
19	0.01	0.02	0.03	0.01	0.00	0.00	0.02	0.00	0.02	0.03	0.01	0.02	0.02	0.01	0.03	0.02
20	0.00	0.00		0.04		0.01	0.00		0.01	0.00	0.00	0.00	0.00	0.00	0.01	
21	0.00		0.01	0.00		0.00	0.01	0.01		0.00	0.01			0.00	0.00	
22	0.00								0.00		0.01	0.02		0.01	0.00	
23			0.01					0.01	0.00							0.00
24																
25																
26																
27																

Table 7: Sex-specific southern flounder natural mortality rates at age.

	M	
Age	*Female*	*Male*
1	*0.65*	*0.57*
2	*0.55*	*0.51*
3	*0.50*	*0.49*
4+	*0.47*	*0.49*

Table 8: FAO proposed guideline for indices of productivity for exploited fish species.

Parameter	***Productivity***			***Species***	
	Low	*Medium*	*High*	*Southern Flounder*	***Score***
M	*<0.2*	*0.2 - 0.5*	*>0.5*	***0.5***	*2*
K	*<0.15*	*0.15 - 0.33*	*>0.33*	***0.51***	*3*
tmat	*>8*	*3.3 - 8*	*<3.3*	***3***	*3*
tmax	*>25*	*14 - 25*	*<14*	***8***	*3*
Examples	*orange roughy, many sharks*	*cod, hake*	*sardine, anchovy*	***Southern Flounder Productivity Score = 2.75 (high)***	

Table 9: Annual sample sizes, percent positive samples, nominal CPUE, standardized index of abundance, and corresponding coefficients of variation for age-0 southern flounder derived from the LDWF fishery-independent marine trawl survey. Nominal cpue and the standardized index of abundance have been normalized to their individual long-term means for comparison.

Year	*n*	*% Positive*	*Nominal CPUE*	*Index*	*CV*
1981	*296*	*5.07*	*1.08*	*0.44*	*0.31*
1982	*353*	*15.01*	*1.25*	*1.69*	*0.17*
1983	*542*	*18.27*	*1.47*	*2.56*	*0.13*
1984	*530*	*12.45*	*0.86*	*1.07*	*0.15*
1985	*514*	*5.45*	*0.89*	*0.49*	*0.22*
1986	*550*	*7.64*	*0.72*	*0.60*	*0.18*
1987	*396*	*15.40*	*0.97*	*1.45*	*0.17*
1988	*524*	*9.16*	*0.86*	*0.76*	*0.17*
1989	*485*	*9.07*	*1.36*	*0.90*	*0.19*
1990	*480*	*14.58*	*1.53*	*1.69*	*0.15*
1991	*574*	*14.63*	*1.79*	*1.54*	*0.14*
1992	*569*	*5.62*	*0.73*	*0.41*	*0.21*
1993	*525*	*9.90*	*0.84*	*0.79*	*0.17*
1994	*525*	*12.76*	*0.87*	*1.12*	*0.15*
1995	*551*	*6.72*	*1.04*	*0.63*	*0.20*
1996	*595*	*11.26*	*0.78*	*0.94*	*0.15*
1997	*561*	*15.69*	*0.83*	*1.31*	*0.13*
1998	*566*	*12.54*	*1.13*	*1.28*	*0.15*
1999	*565*	*8.85*	*0.80*	*0.70*	*0.17*
2000	*577*	*9.36*	*0.72*	*0.70*	*0.16*
2001	*572*	*4.20*	*0.85*	*0.35*	*0.25*
2002	*563*	*10.30*	*1.59*	*1.03*	*0.16*
2003	*564*	*10.46*	*0.93*	*0.93*	*0.15*
2004	*570*	*15.96*	*1.14*	*1.60*	*0.13*
2005	*562*	*8.72*	*1.17*	*0.75*	*0.17*
2006	*526*	*11.79*	*1.00*	*1.05*	*0.16*
2007	*569*	*11.25*	*0.75*	*0.91*	*0.15*
2008	*536*	*14.18*	*0.78*	*1.20*	*0.15*
2009	*597*	*8.04*	*0.91*	*0.74*	*0.17*
2010	*573*	*9.42*	*0.97*	*0.80*	*0.16*
2011	*524*	*11.45*	*0.76*	*0.98*	*0.16*
2012	*561*	*13.37*	*0.88*	*1.11*	*0.14*
2013	*592*	*6.42*	*0.75*	*0.48*	*0.20*

Table 10: Sex-specific probabilities of age given length used in age assignments of southern flounder fishery landings 1981-2001.

	Female					Male				
FL_in	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Age_0*	*Age_1*	*Age_2*	*Age_3*	*Age_4+*
5	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
6	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
7	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
8	0.56	0.44	0.00	0.00	0.00	0.88	0.12	0.00	0.00	0.00
9	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
10	0.00	1.00	0.00	0.00	0.00	0.00	0.98	0.02	0.00	0.00
11	0.00	1.00	0.00	0.00	0.00	0.00	0.42	0.26	0.07	0.24
12	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.71
13	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.88
14	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.95
15	0.00	0.84	0.16	0.00	0.00	0.00	0.00	0.00	0.02	0.98
16	0.00	0.02	0.89	0.05	0.04	0.00	0.00	0.00	0.01	0.99
17	0.00	0.00	0.63	0.16	0.21	0.00	0.00	0.00	0.00	1.00
18	0.00	0.00	0.17	0.22	0.61	0.00	0.00	0.00	0.00	1.00
19	0.00	0.00	0.02	0.13	0.86	0.00	0.00	0.00	0.00	1.00
20	0.00	0.00	0.00	0.05	0.95	0.00	0.00	0.00	0.00	1.00
21	0.00	0.00	0.00	0.02	0.98	0.00	0.00	0.00	0.00	1.00
22	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.00	0.00	1.00
23	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00
24	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00
25	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00

Table 11: Annual commercial length-at-age samples used in age assignments of commercial southern flounder landings 2002-2013.

Female - 2002					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	3				3
11	6				6
12	15	1	1		17
13	21	2	1		24
14	11	10	2		23
15	16	8			24
16	14	6	1		21
17	7	9			16
18	16	3			19
19	24	3			27
20	7				7
21	3	1			4
22		1			1
23		3			3
24			1		1
25					
Total	143	47	6		196

Male - 2002					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	12				12
11	13				13
12	3	2			5
13	2	1			3
14	2	3			5
15	1				1
16					
17		1			1
18					
19					
20					
21					
22					
23					
24					
25					
Total	33	7			40

Female - 2003					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	8				8
11	20				20
12	26	4	1		31
13	19	2			21
14	42	11			53
15	28	11			39
16	14	5			19
17	9	6	4	1	20
18	2	2		1	5
19		1			1
20		2	1		3
21					
22	1		1		2
23			1		1
24					
25					
Total	169	44	8	2	223

Male - 2003					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	5	1			6
11	17	1			18
12	10	1			11
13	3	2			5
14	3	2			5
15	3	2			5
16		1			1
17	1			2	3
18	1		1	1	3
19					
20					
21					
22					
23					
24					
25					
Total	43	10	1	3	57

Female - 2004					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9		1			1
10	3				3
11	16				16
12	34	1			35
13	22	9			31
14	15	16	1	1	33
15	22	7	2		31
16	6	5	4	1	16
17	2	6	1		9
18	1	1	2		4
19			2		2
20				1	1
21		1			1
22					
23					
24					
25					
Total	121	47	12	3	183

Male - 2004					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	1				1
9	20				20
10	28				28
11	19				19
12	1	1		1	3
13		4			4
14	1				1
15		1			1
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	70	6	0	1	77

Table 11 (continued):

Female - 2005					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10					
11	2				2
12	6	11	1		18
13	15	35	1		51
14	2	27			29
15	6	13	2		21
16	3	4	1	1	9
17	14	3	2	1	20
18	6				6
19		1			1
20			3		3
21				1	1
22					
23					
24					
25					
Total	54	94	10	3	161

Male - 2005					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10					
11	2				2
12	2				2
13		2		1	3
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	4	2	0	1	7

Female - 2006					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	4				4
10	1				1
11	3				3
12	25				25
13	54	2			56
14	61	7			68
15	39	10	4		53
16	26	15	5		46
17	12	14	2		28
18	4	6	2		12
19	2	10	3		15
20	2	6	3	1	12
21	1	1	1		3
22			1		1
23					
24					
25					
Total	234	71	21	1	327

Male - 2006					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	1				1
9	5				5
10	3				3
11	15				15
12	5				5
13	2				2
14	2				2
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	33	0	0	0	33

Female - 2007					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	2				2
11	4				4
12	6	2			8
13	22	8			30
14	31	10			41
15	38	13			51
16	19	8			27
17	17	5			22
18	6	1			7
19	1				1
20					
21					
22					
23					
24					
25					
Total	146	47	0	0	193

Male - 2007					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	2				2
10	3				3
11					
12	1				1
13	1				1
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	7	0	0	0	7

Table 11 (continued):

Female - 2008					
FL_in	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8					
9					
10	*1*	*.*	*.*		*1*
11	*2*	*3*	*.*		*5*
12	*20*	*5*	*2*		*27*
13	*25*	*8*	*.*		*33*
14	*30*	*11*	*1*		*42*
15	*24*	*13*	*.*		*37*
16	*15*	*9*	*2*		*26*
17	*2*	*2*	*1*		*5*
18					
19					
20					
21					
22					
23					
24					
25					
Total	*119*	*51*	*6*	*0*	*176*

Male - 2008					
FL_in	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8					
9					
10					
11					
12		*3*	*1*		*4*
13		*1*	*2*		*3*
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	*0*	*4*	*3*	*0*	*7*

Female - 2009					
FL_in	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8					
9					
10					
11					
12					
13					
14	*1*	*3*			*4*
15	*1*	*4*			*5*
16	*3*	*3*			*6*
17	*2*	*3*			*5*
18	*1*	*3*	*2*		*6*
19		*6*	*2*		*8*
20		*5*			*5*
21			*2*		*2*
22			*1*	*1*	*2*
23		*1*			*1*
24					
25					
Total	*8*	*28*	*7*	*1*	*44*

Male - 2009					
FL_in	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8					
9					
10					
11					
12					
13		*1*			*1*
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total		*1*			*1*

Female - 2010					
FL_in	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8					
9					
10					
11					
12	*1*	*1*			*2*
13	*8*				*8*
14	*17*				*17*
15	*2*				*2*
16	*1*				*1*
17			*1*		*1*
18	*1*				*1*
19					
20					
21					
22					
23					
24					
25					
Total	*30*	*1*	*1*		*32*

Male - 2010					
FL_in	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Total*
8					
9					
10	*7*				*7*
11	*37*	*1*			*38*
12	*17*	*1*		*1*	*19*
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	*61*	*2*		*1*	*64*

Table 11 (continued):

Female - 2011					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	1				1
11					
12	1				1
13	3				3
14	2				2
15	3				3
16	5	2			7
17	8				8
18	1				1
19					
20					
21					
22					
23					
24					
25					
Total	24	2			26

Male - 2011					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	1				1
10	1				1
11	5	1			6
12	15	3			18
13	4				4
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	26	4			30

Female - 2012					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10					
11	1				1
12	2				2
13	8				8
14	1				1
15	5				5
16					
17					
18	1				1
19					
20					
21					
22					
23					
24					
25					
Total	18				18

Male - 2012					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	1				1
11					
12	2				2
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	3				3

Female - 2013					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10					
11					
12	1				1
13	4				4
14	9	3			12
15	28	10	2		40
16	7	10	2		19
17	7	8		1	16
18	2	1			3
19		5			5
20		1		1	2
21					
22		1			1
23					
24					
25					
Total	58	39	4	2	103

Male - 2013					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10					
11					
12					
13					
14	1				1
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	1				1

Table 12: Annual recreational length-at-age samples used in age assignments of recreational southern flounder landings 2002-2013.

Female - 2002					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	2				2
9	5				5
10	28	2			30
11	57	1	2		60
12	118	5			123
13	115	2			117
14	115	17	1		133
15	70	24	3		97
16	49	32	1	1	83
17	23	21	1		45
18	16	14	1		31
19	4	8		1	13
20		4	1	2	7
21	1	2		2	5
22					
23		1		1	2
24					
25		1			1
26					
27					
Total	603	134	10	7	754

Male - 2002					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	1				1
9	7				7
10	17	1			18
11	40				40
12	18				18
13	5				5
14	3				3
15		1			1
16	2	3	1		6
17		1			1
18	1	1	1		3
19					
20					
21					
22					
23					
24					
25					
26					
27					
Total	94	7	2		103

Female - 2003					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
6	1				1
7					
8					
9	4				4
10	23	2			25
11	51	3			54
12	138	24			162
13	153	61			214
14	117	69		2	188
15	71	70	2		143
16	38	44	6		88
17	13	36	8		57
18	8	21	4		33
19	3	6	4		13
20		9	6		15
21		2	2		4
22					
23			2		2
24					
25					
Total	620	347	34	2	1003

Male - 2003					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
6					
7					
8	1				1
9	5	2			7
10	24				24
11	25	2			27
12	12	7			19
13	4				4
14	5	3			8
15	1	3			4
16		2			2
17			1		1
18					
19					
20					
21					
22					
23					
24					
25					
Total	77	19	1	0	97

Female - 2004					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	18	1			19
10	65	5			70
11	85	2			87
12	183	23	1		207
13	128	56	2		186
14	104	87	2		193
15	49	69	15		133
16	29	36	19		84
17	9	28	19		56
18		13	18		31
19		2	4	1	7
20		1	5		6
21	1	1	4		6
22		1			1
23			1		1
24					
25					
Total	671	325	90	1	1087

Male - 2004					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	17				17
10	32				32
11	28	3			31
12	2	1			3
13	1	2			3
14	1				1
15		1			1
16	1		1		2
17			1		1
18					
19					
20					
21					
22					
23					
24					
25					
Total	82	7	2		91

Table 12 (continued):

Female - 2005					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	1				1
10	11				11
11	40	8			48
12	51	40			91
13	74	63	5		142
14	74	73	15		162
15	39	59	33	3	134
16	11	53	31	6	101
17	5	29	19	3	56
18	1	11	7	4	23
19	2	5		3	10
20	.	2	2	1	5
21	1	1		2	4
22				1	1
23			1		1
24				1	1
25					
26					
27	1	.	.		1
Total	311	344	113	24	792

Male - 2005					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	2				2
10	7	2			9
11	16	3			19
12	8	3			11
13	1	3			4
14	1				1
15		2			2
16			1		1
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
Total	35	13	1		49

Female - 2006					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
6					
7					
8					
9	6				6
10	24		1		25
11	72	1			73
12	177	2	1		180
13	258	10	2		270
14	206	15	2		223
15	107	27	10	1	145
16	63	24	7	1	95
17	26	30	10	1	67
18	9	15	6		30
19	3	5	3		11
20	1	4	3	1	9
21		2	2	.	4
22				1	1
23				1	1
24			1		1
25					
Total	952	135	48	6	1141

Male - 2006					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
6					
7					
8					
9	2				2
10	16				16
11	17	1			18
12	9	1			10
13	1	1	1		3
14	1				1
15	1	1			2
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	47	4	1		52

Female - 2007					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	3				3
10	6				6
11	22	2			24
12	50	2			52
13	73	3			76
14	89	20			109
15	68	19			87
16	28	17	2		47
17	13	28	1	1	43
18	6	11	4		21
19	3	8			11
20		5	1	3	9
21					
22			2	2	4
23		1			1
24					
25					
Total	361	116	10	6	493

Male - 2007					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	1				1
9	2				2
10	8				8
11	25	1			26
12	7				7
13	1	1			2
14			1	2	3
15	1		1		2
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	45	2	2	2	51

Table 12 (continued):

Female - 2008					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	7				7
11	35				35
12	72	3			75
13	86	16			102
14	72	26	1		99
15	45	33			78
16	19	46	2		67
17	11	24	3		38
18	5	10	4		19
19	1	1	4	2	8
20	1		4	1	6
21	2		4		6
22		2	1		3
23				1	1
24					
25					
Total	356	161	23	4	544

Male - 2008					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	3				3
10	9				9
11	16	2			18
12	5	1			6
13	7				7
14	2	2			4
15					
16					
17			1		1
18			1		1
19					
20					
21					
22					
23					
24					
25					
Total	42	5	2		49

Female - 2009					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	1				1
10	1	1			2
11	18	1			19
12	51	1			52
13	69	8	1		78
14	71	13	1		85
15	47	27	4		78
16	28	34	1		63
17	16	9	5		30
18	4	12	3		19
19	1	2	4	1	8
20		2	2		4
21			1		1
22			1		1
23					
24					
25					
26					
Total	307	110	23	1	441

Male - 2009					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	1				1
10	7	1			8
11	8	1			9
12	5	2			7
13	2	1	1		4
14		1		1	2
15					
16		1			1
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
Total	23	7	1	1	32

Female - 2010					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	1				1
10	5	1			6
11	11	1			12
12	39	5	1		45
13	24	10			34
14	35	27			62
15	19	27	3		49
16	7	22	3		32
17	1	8	3		12
18		4	1		5
19	1	1	1	1	4
20	1	1			2
21					
22					
23					
24					
25					
Total	144	107	12	1	264

Male - 2010					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	5				5
11	7				7
12	2				2
13	1				1
14					
15	1				1
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Total	16				16

Table 12 (continued):

Female - 2011					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	6				6
11	15	1			16
12	39	1			40
13	44	7			51
14	59	9			68
15	32	18			50
16	21	21	2		44
17	11	13	3		27
18	9	6	2	1	18
19	1		1		2
20	2			2	4
21			1	1	2
22	1		1		2
23				1	1
24					
25					
Total	240	76	10	5	331

Male - 2011					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	1				1
9	1				1
10	9				9
11	10	3			13
12	4				4
13	1	1			2
14					
15	1				1
16	1				1
17					
18		1			1
19					
20					
21					
22					
23					
24					
25					
Total	28	5			33

Female - 2012					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	1				1
9	1				1
10	10				10
11	21				21
12	44	2			46
13	38	6			44
14	36	10			46
15	17	11	2		30
16	5	22	1		28
17	2	18	2		22
18	2	7	7		16
19		5	3		8
20	1	4	3		8
21			1		1
22			1		1
23					
24					
25					
26					
Total	178	85	20	0	283

Male - 2012					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9	1				1
10	6				6
11	5	1			6
12	4				4
13	2				2
14	3	1			4
15	1		1		2
16		1			1
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
Total	22	3	1	0	26

Female - 2013					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8	1				1
9	1				1
10	10				10
11	43	1			44
12	34	1			35
13	21	6			27
14	25	13			38
15	19	16	1		36
16	11	14	1		26
17	17	15	1		33
18		12	1		13
19					
20	1	1		1	3
21		1		1	2
22	1				1
23					
24					
25					
Total	184	80	4	2	270

Male - 2013					
FL_in	Age_1	Age_2	Age_3	Age_4+	Total
8					
9					
10	4				4
11	8				8
12	6	2			8
13		1			1
14	3				3
15		1			1
16	1				1
17					
18	1				1
19					
20					
21					
22					
23					
24					
25					
Total	23	4			27

Table 13: Annual commercial southern flounder catch-at-age and yield (pounds).

Commercial Catch-at-age					
Year	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Yield (lbs)*
1981	60,626	12,037	1,956	10,081	136,962
1982	88,416	17,554	2,853	14,702	199,742
1983	122,239	24,269	3,944	20,327	276,151
1984	156,372	31,046	5,045	26,003	353,263
1985	234,596	46,576	7,569	39,010	529,979
1986	365,202	72,507	11,783	60,728	825,034
1987	415,240	82,441	13,397	69,049	938,076
1988	225,878	44,846	7,288	37,560	510,285
1989	217,805	43,243	7,027	36,218	492,047
1990	201,724	40,050	6,508	33,544	455,718
1991	306,464	60,845	9,888	50,961	692,338
1992	347,286	68,950	11,205	57,749	784,560
1993	397,887	78,996	12,837	66,163	898,874
1994	233,797	117,436	24,687	104,482	974,689
1995	192,527	71,305	11,012	39,914	533,172
1996	23,391	7,440	1,416	4,865	61,755
1997	27,693	6,733	2,813	13,965	94,883
1998	40,837	9,929	4,149	20,593	139,916
1999	41,068	9,985	4,172	20,709	140,709
2000	51,765	12,586	5,259	26,103	177,359
2001	26,344	6,405	2,676	13,284	90,260
2002	28,067	6,510	925	4,107	78,475
2003	36,357	7,150	1,272	2,686	62,855
2004	51,997	10,736	2,600	3,624	72,041
2005	4,587	8,863	725	1,292	21,566
2006	38,623	9,301	2,619	2,208	82,116
2007	34,249	9,746	731	4,226	76,916
2008	37,435	15,365	2,002	2,597	77,227
2009	61,538	11,273	3,244	16,468	130,604
2010	107,553	1,143	222	1,004	79,692
2011	99,447	19,810	3,273	7,400	154,269
2012	61,310	12,438	2,260	5,724	97,043
2013	24,055	13,539	2,311	5,655	89,114

Table 14: Annual mean weight at age (pounds) of commercial southern flounder landings.

Commercial Mean Weight-at-age				
Year	*Age_1*	*Age_2*	*Age_3*	*Age_4+*
1981-1993	1.20	2.04	2.34	3.49
1994	1.28	2.11	2.65	3.47
1995	1.27	2.05	2.48	2.90
1996	1.23	2.10	2.48	2.84
1997-2001	0.90	2.17	2.84	3.39
2002	1.69	2.03	1.61	3.96
2003	1.12	1.62	2.25	2.85
2004	0.82	1.54	1.96	2.13
2005	1.30	1.27	1.78	2.36
2006	1.25	2.38	2.54	2.37
2007	1.37	1.67	2.74	2.77
2008	1.28	1.48	1.46	1.38
2009	0.70	2.04	2.64	3.41
2010	0.70	1.86	2.37	1.79
2011	0.91	2.07	2.31	2.10
2012	0.91	2.08	2.18	1.86
2013	1.66	1.97	2.20	3.10

Table 15: Annual recreational southern flounder catch-at-age and yield (pounds).

Recreational Catch-at-age					
Year	*Age_1*	*Age_2*	*Age_3*	*Age_4+*	*Yield (lbs)*
1981	119,954	17,947	2,314	10,920	182,400
1982	296,841	37,671	8,586	40,588	450,276
1983	196,087	84,290	17,947	50,967	598,814
1984	99,549	15,173	3,623	12,680	177,367
1985	322,746	45,722	8,998	36,232	579,771
1986	185,767	19,861	2,855	10,658	236,781
1987	122,801	17,629	3,351	10,418	173,386
1988	248,616	63,492	12,868	54,235	589,604
1989	162,591	43,672	8,167	24,658	349,754
1990	268,230	44,738	7,482	26,155	423,621
1991	359,164	46,991	8,461	37,705	575,155
1992	266,245	60,083	11,075	40,828	534,018
1993	199,228	55,247	10,291	27,992	402,858
1994	227,464	45,256	8,255	28,787	424,334
1995	184,929	38,843	6,774	21,663	313,582
1996	214,219	37,525	8,480	34,837	414,967
1997	237,362	46,659	8,615	29,268	427,402
1998	184,256	23,821	4,732	17,117	280,548
1999	270,692	59,945	11,236	35,464	521,993
2000	250,720	71,447	14,675	47,892	603,865
2001	159,989	51,932	10,050	34,573	419,231
2002	206,536	38,203	3,304	5,873	313,463
2003	233,482	111,095	7,778	11,981	468,913
2004	286,012	123,917	27,639	25,055	569,165
2005	110,086	99,410	27,179	13,584	337,186
2006	226,413	35,116	12,255	11,018	403,945
2007	230,824	64,168	4,294	12,325	443,907
2008	133,761	56,245	5,611	15,063	314,599
2009	173,414	57,734	8,979	19,332	401,143
2010	157,617	106,210	14,628	26,441	431,432
2011	241,129	78,690	8,804	23,385	537,937
2012	196,697	92,945	15,376	23,032	484,783
2013	356,793	241,236	16,284	33,711	1,061,382

Table 16: Annual mean weight at age (pounds) of recreational southern flounder landings.

Recreational Mean Weight-at-age				
Year	Age_1	Age_2	Age_3	Age_4+
1981	0.98	1.89	2.16	2.40
1982	0.78	1.97	2.47	3.01
1983	1.27	2.03	2.64	2.57
1984	1.11	1.98	2.44	2.22
1985	1.16	2.03	2.38	2.55
1986	0.96	1.90	1.78	1.54
1987	0.90	1.99	2.16	1.95
1988	1.09	2.05	2.56	2.89
1989	1.08	2.08	2.42	2.57
1990	0.94	1.99	2.23	2.52
1991	1.00	1.99	2.23	2.74
1992	1.04	2.02	2.44	2.69
1993	0.99	2.09	2.35	2.36
1994	1.05	2.07	2.32	2.52
1995	0.89	2.02	2.35	2.55
1996	1.04	2.04	2.47	2.72
1997	1.01	2.08	2.32	2.44
1998	1.00	2.03	2.18	2.20
1999	1.08	2.05	2.37	2.28
2000	1.13	2.12	2.45	2.78
2001	1.18	2.10	2.49	2.79
2002	1.12	1.79	1.52	1.53
2003	1.09	1.56	2.61	1.77
2004	0.95	1.47	2.06	2.35
2005	1.04	1.38	1.79	2.72
2006	1.24	2.03	2.14	2.28
2007	1.22	2.03	2.24	1.76
2008	1.16	1.85	2.41	2.82
2009	1.27	1.80	2.08	2.97
2010	1.10	1.56	2.12	2.32
2011	1.26	1.84	2.32	2.91
2012	1.05	1.94	2.46	2.58
2013	1.40	1.88	2.14	2.20

Table 17: Summary of objective function components and likelihood values of the ASAP base model.

Objective function = 1541			
Component	Lambda	ESS	Obj_fun
Catch_Fleet_Total	2		760
Index_Fit_Total	1		-14
Catch_Age_Comps		3975	316
Index_Age_Comps			
Recruit_devs	1		479

Table 18: Annual southern flounder abundance-at-age and total stock size estimates from the ASAP base model.

Year	Age_1	Age_2	Age_3	Age_4	Totals
1981	772,475	268,747	75,848	988,624	2,105,694
1982	2,073,990	329,124	133,219	616,122	3,152,455
1983	2,402,740	801,207	151,340	418,947	3,774,234
1984	1,424,600	958,501	377,857	320,134	3,081,092
1985	999,313	613,246	479,312	393,161	2,485,032
1986	1,223,270	296,535	231,118	421,009	2,171,932
1987	2,079,950	321,416	101,977	303,871	2,807,214
1988	1,363,420	635,461	123,899	202,658	2,325,438
1989	1,453,620	388,026	232,097	158,823	2,232,566
1990	2,239,990	469,473	155,959	194,457	3,059,879
1991	2,271,110	796,999	203,034	184,842	3,455,985
1992	1,024,070	738,252	321,961	195,313	2,279,596
1993	1,661,580	255,076	243,655	228,670	2,388,981
1994	1,924,640	399,581	81,987	208,791	2,614,999
1995	1,175,040	492,866	134,667	137,211	1,939,784
1996	1,318,930	348,220	185,406	131,933	1,984,489
1997	1,574,660	512,078	160,869	172,262	2,419,869
1998	1,502,330	624,408	240,161	183,674	2,550,573
1999	1,059,380	638,747	308,950	238,384	2,245,461
2000	999,581	384,274	280,056	288,788	1,952,699
2001	690,908	308,681	148,956	283,444	1,431,989
2002	1,325,600	230,925	127,159	226,786	1,910,470
2003	1,413,130	532,697	109,126	197,236	2,252,189
2004	1,970,300	538,342	241,980	167,374	2,917,996
2005	742,020	743,038	242,516	218,567	1,946,141
2006	1,363,340	297,050	350,201	254,098	2,264,689
2007	1,328,920	543,882	139,891	330,317	2,343,010
2008	1,153,090	524,579	254,020	261,670	2,193,359
2009	1,100,690	478,436	254,487	288,383	2,121,996
2010	1,285,490	412,763	214,851	292,417	2,205,521
2011	1,390,050	474,088	182,902	272,709	2,319,749
2012	1,500,680	492,408	203,774	241,173	2,438,035
2013	885,261	568,594	222,960	241,014	1,917,829

Table 19: Annual total age-specific, apical, and average fishing mortality rates for southern flounder estimated from the ASAP base model.

Year	Age_1	Age_2	Age_3	Age_4+	Fmult_total	Avg. F
1981	0.20	0.15	0.10	0.06	0.20	0.13
1982	0.30	0.23	0.15	0.09	0.30	0.25
1983	0.27	0.20	0.14	0.08	0.27	0.23
1984	0.19	0.14	0.10	0.06	0.19	0.15
1985	0.56	0.43	0.29	0.18	0.56	0.42
1986	0.69	0.52	0.36	0.23	0.69	0.54
1987	0.53	0.41	0.28	0.18	0.53	0.47
1988	0.61	0.46	0.31	0.19	0.61	0.51
1989	0.48	0.36	0.25	0.16	0.48	0.41
1990	0.38	0.29	0.20	0.12	0.38	0.34
1991	0.47	0.36	0.24	0.15	0.47	0.42
1992	0.74	0.56	0.38	0.24	0.74	0.59
1993	0.77	0.59	0.40	0.26	0.77	0.67
1994	0.71	0.54	0.37	0.24	0.71	0.64
1995	0.57	0.43	0.29	0.19	0.57	0.49
1996	0.30	0.22	0.15	0.09	0.30	0.26
1997	0.27	0.21	0.14	0.08	0.27	0.24
1998	0.21	0.16	0.11	0.07	0.21	0.17
1999	0.36	0.28	0.18	0.11	0.36	0.29
2000	0.52	0.40	0.27	0.16	0.52	0.41
2001	0.44	0.34	0.22	0.14	0.44	0.34
2002	0.26	0.20	0.13	0.08	0.26	0.23
2003	0.32	0.24	0.16	0.09	0.32	0.27
2004	0.33	0.25	0.16	0.10	0.33	0.29
2005	0.27	0.20	0.13	0.08	0.27	0.21
2006	0.27	0.20	0.14	0.08	0.27	0.22
2007	0.28	0.21	0.14	0.08	0.28	0.23
2008	0.23	0.17	0.12	0.07	0.23	0.18
2009	0.33	0.25	0.17	0.10	0.33	0.26
2010	0.35	0.27	0.18	0.11	0.35	0.28
2011	0.39	0.30	0.20	0.12	0.39	0.32
2012	0.32	0.24	0.16	0.10	0.32	0.27
2013	0.82	0.63	0.41	0.24	0.82	0.64

Table 20: Limit reference point estimates for the Louisiana southern flounder stock. Spawning stock biomass and yield units are pounds x 10^3. Fishing mortality units are $year^{-1}$.

Reference Points		
Parameter	*Derivation*	*Value/Estimate*
SPR_{limit}	*RS 56:325.4*	*30%*
$F_{30\%}$	*Equation 27 And* SPR_{limit}	*0.60*
$SSB_{30\%}$	*Equation 27 And* SPR_{limit}	*837*
$Yield_{30\%}$	*Equation 27 And* SPR_{limit}	*883*

Table 21: Sensitivity analysis table: current estimates are taken as the geometric mean of the last three years of the assessment (2011-2013). Spawning stock biomass and yield units are pounds x 10^3. Fishing mortality units are $year^{-1}$.

Model run	*negLL*	$Yield_{30\%}$	$F_{30\%}$	$SSB_{30\%}$	$F_{current}/F_{30\%}$	$SSB_{current}/SSB_{30\%}$
Base Model	*1,541*	*883*	*0.60*	*837*	*0.64*	*1.76*
1 (h=1.0)	*1,539*	*918*	*0.59*	*870*	*0.67*	*1.63*
2 (h=0.9)	*1,540*	*890*	*0.59*	*845*	*0.67*	*1.68*
3 (h=0.8)	*1,541*	*861*	*0.60*	*816*	*0.64*	*1.81*
4 (h=0.7)	*1,541*	*798*	*0.60*	*757*	*0.64*	*1.97*
5 Yield lambda (X8)	*6,857*	*906*	*0.60*	*860*	*0.61*	*1.82*
6 Survey lambda (X8)	*1,373*	*883*	*0.60*	*838*	*0.63*	*1.82*
7 Commercial yield lambda (X0.2)	*1,254*	*843*	*0.59*	*799*	*0.70*	*1.67*

11. Figures

Figure 1: Reported commercial flatfish landings (pounds x 10^3) for the Gulf of Mexico derived from NOAA-Fisheries statistical records and the LDWF trip ticket program (Note: NOAA did not distinguish between southern flounder and other flatfish species prior to 2000 in Louisiana).

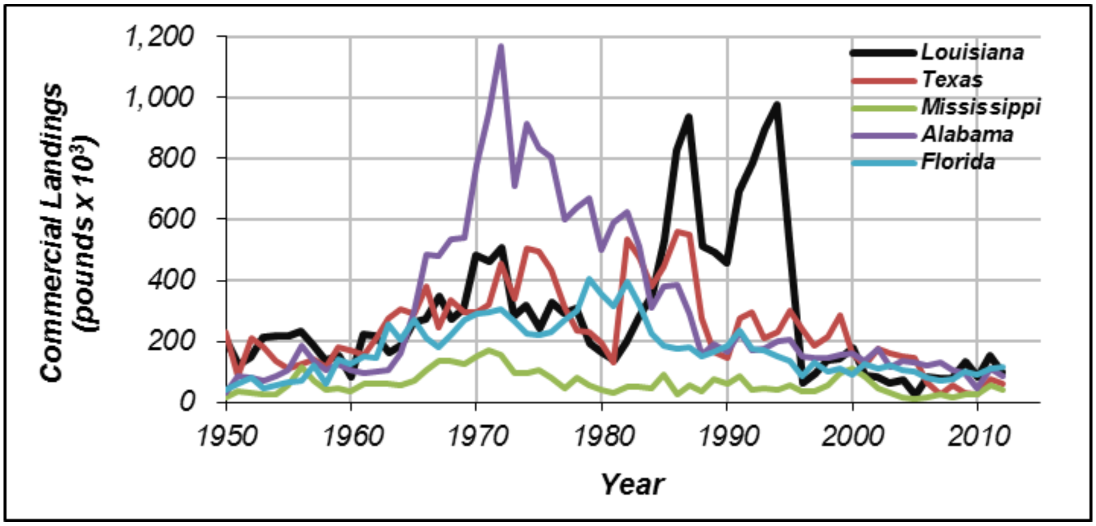


Figure 2: Estimated recreational southern flounder *Paralichthys lethostigma* landings (pounds x 10^3) of the Gulf of Mexico derived from MRFSS/MRIP.

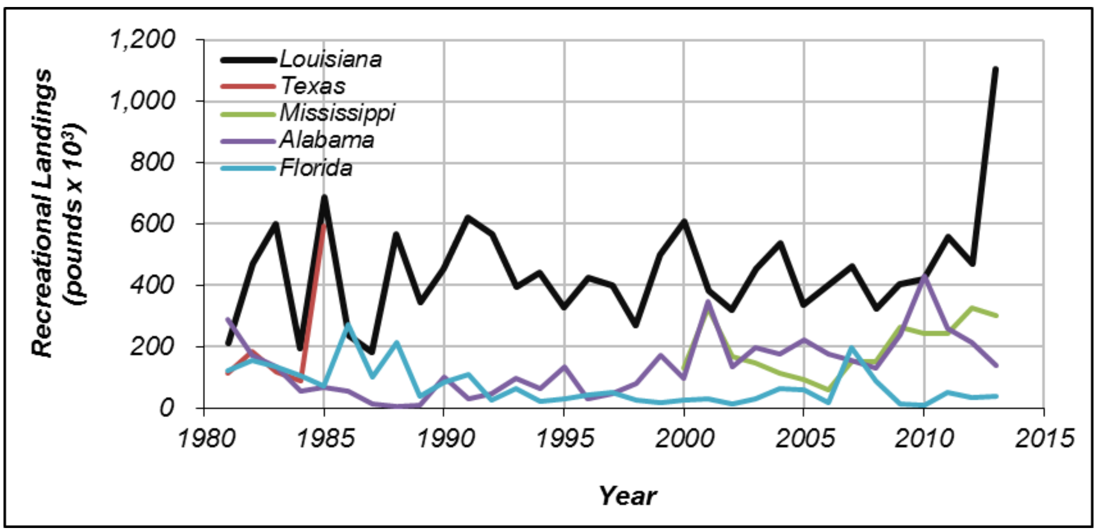


Figure 3: Standardized index of abundance, nominal catch rates, and 95% confidence intervals of the standardized index for age-1 southern flounder derived from the LDWF marine trawl net survey. Each time-series has been normalized to its individual long-term mean for comparison.

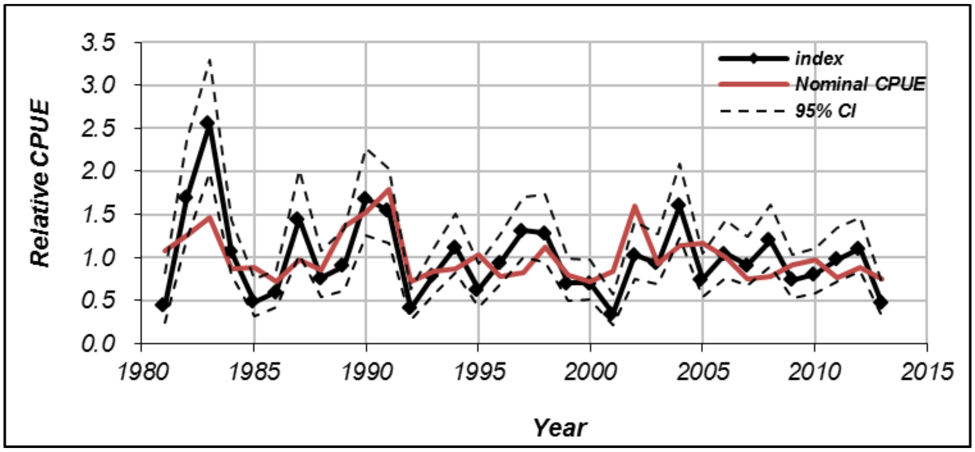


Figure 4: Observed and ASAP base model estimated commercial yield (top) and standardized residuals (bottom).

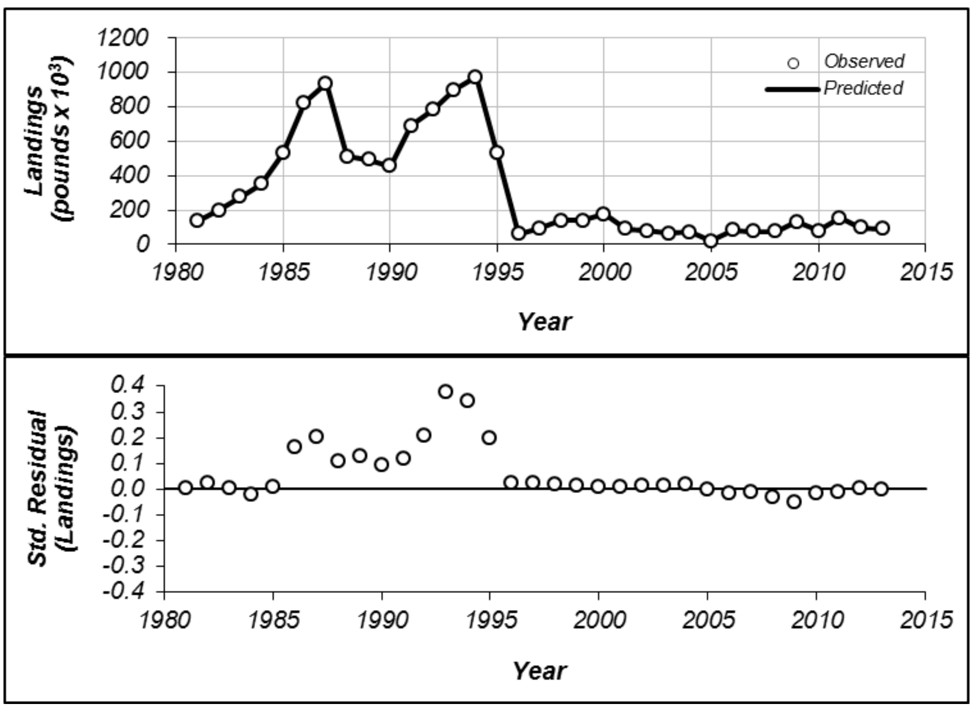


Figure 5: Observed and ASAP base model estimated recreational yield (top) and standardized residuals (bottom).

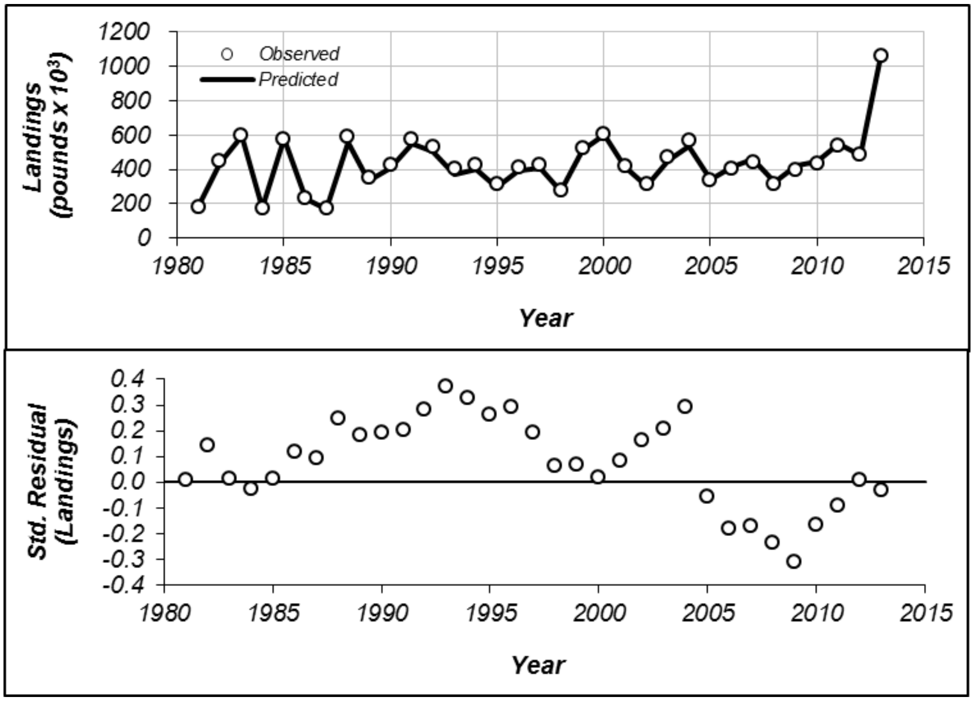


Figure 6: Observed and ASAP base model estimated age-1 survey CPUE (top) and standardized residuals (bottom).

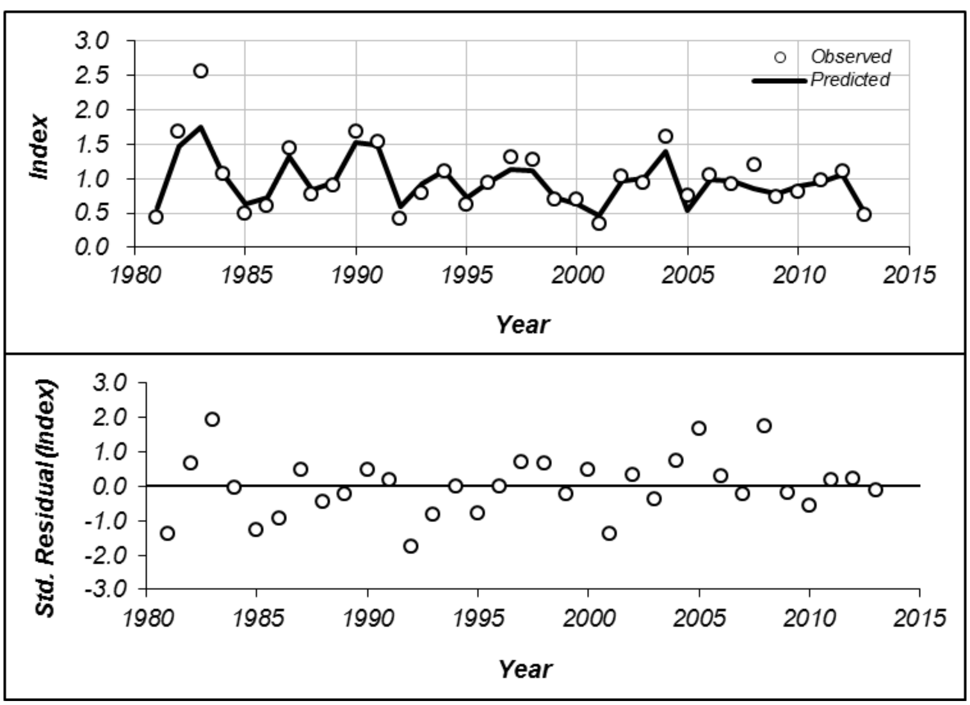


Figure 7: Annual observed (open circles) and ASAP estimated (bold lines) commercial southern flounder harvest age compositions.

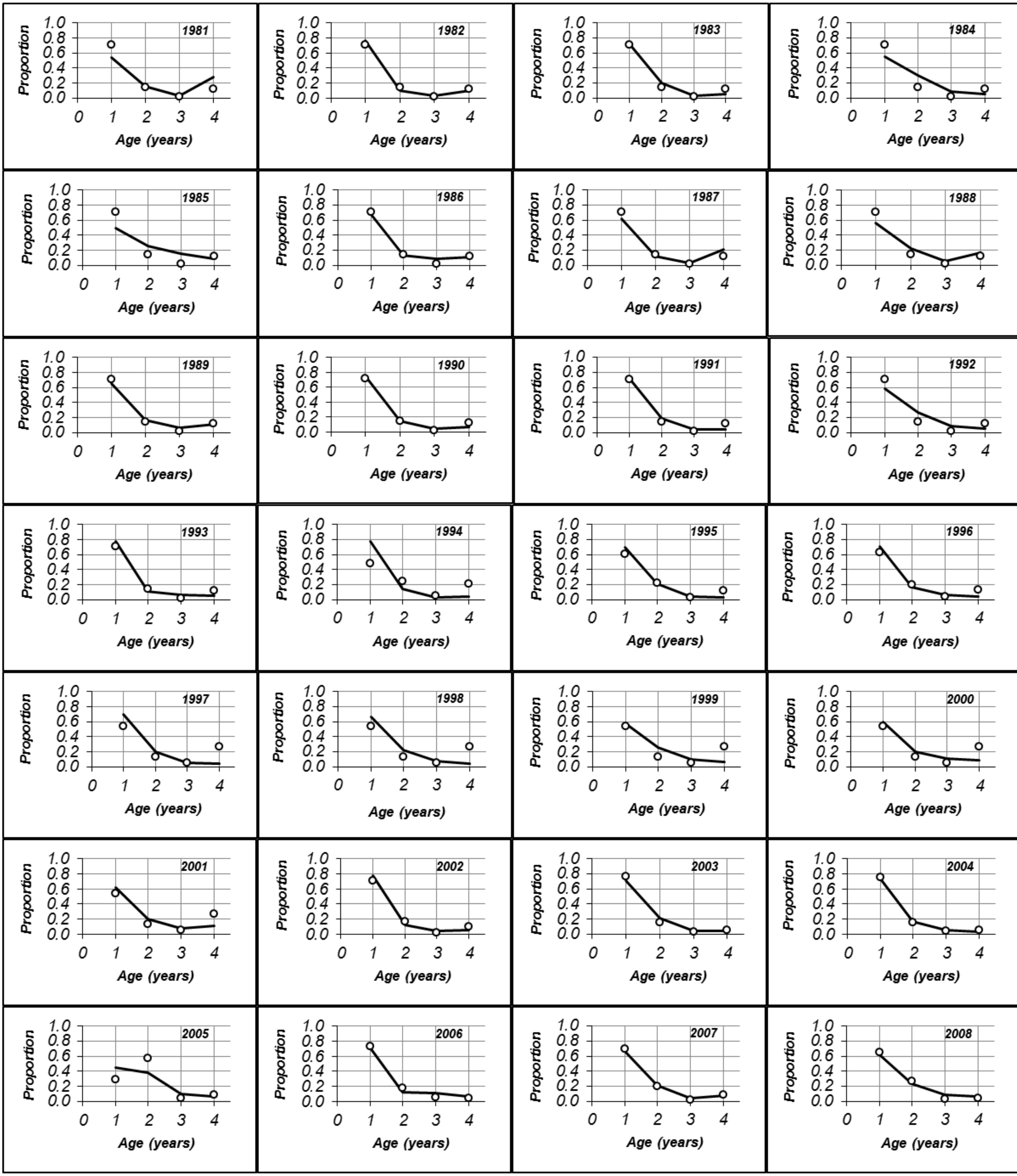


Figure 7 (continued):

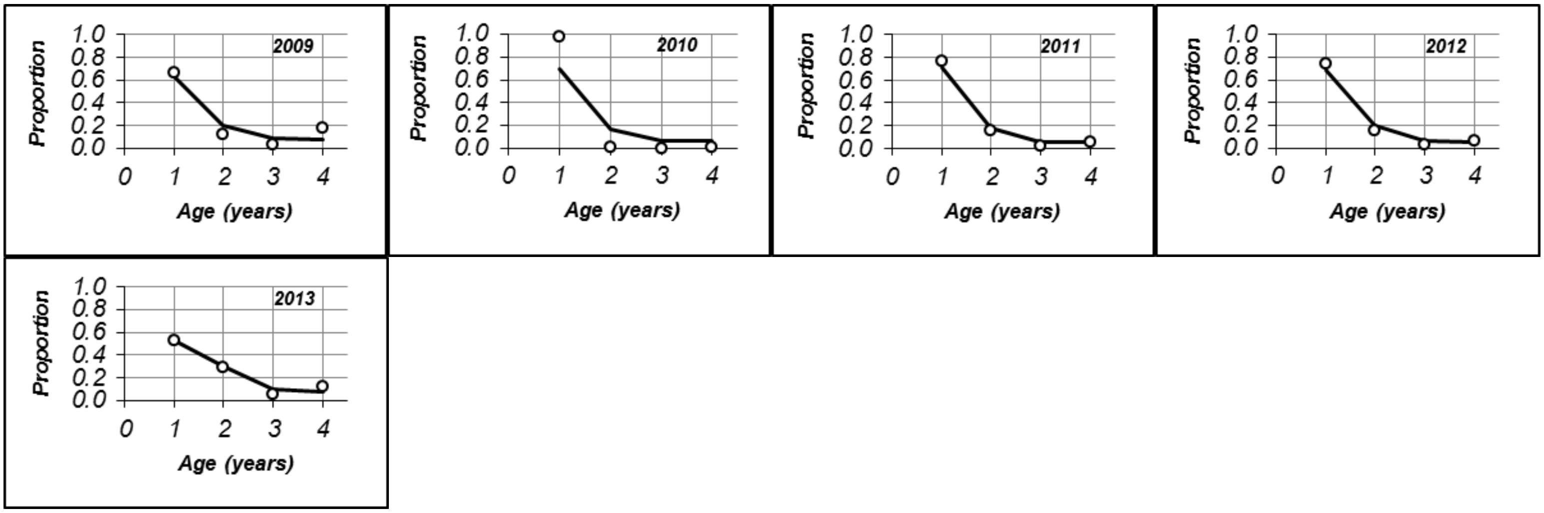


Figure 8: Annual observed (open circles) and ASAP estimated (bold lines) recreational southern flounder harvest age compositions.

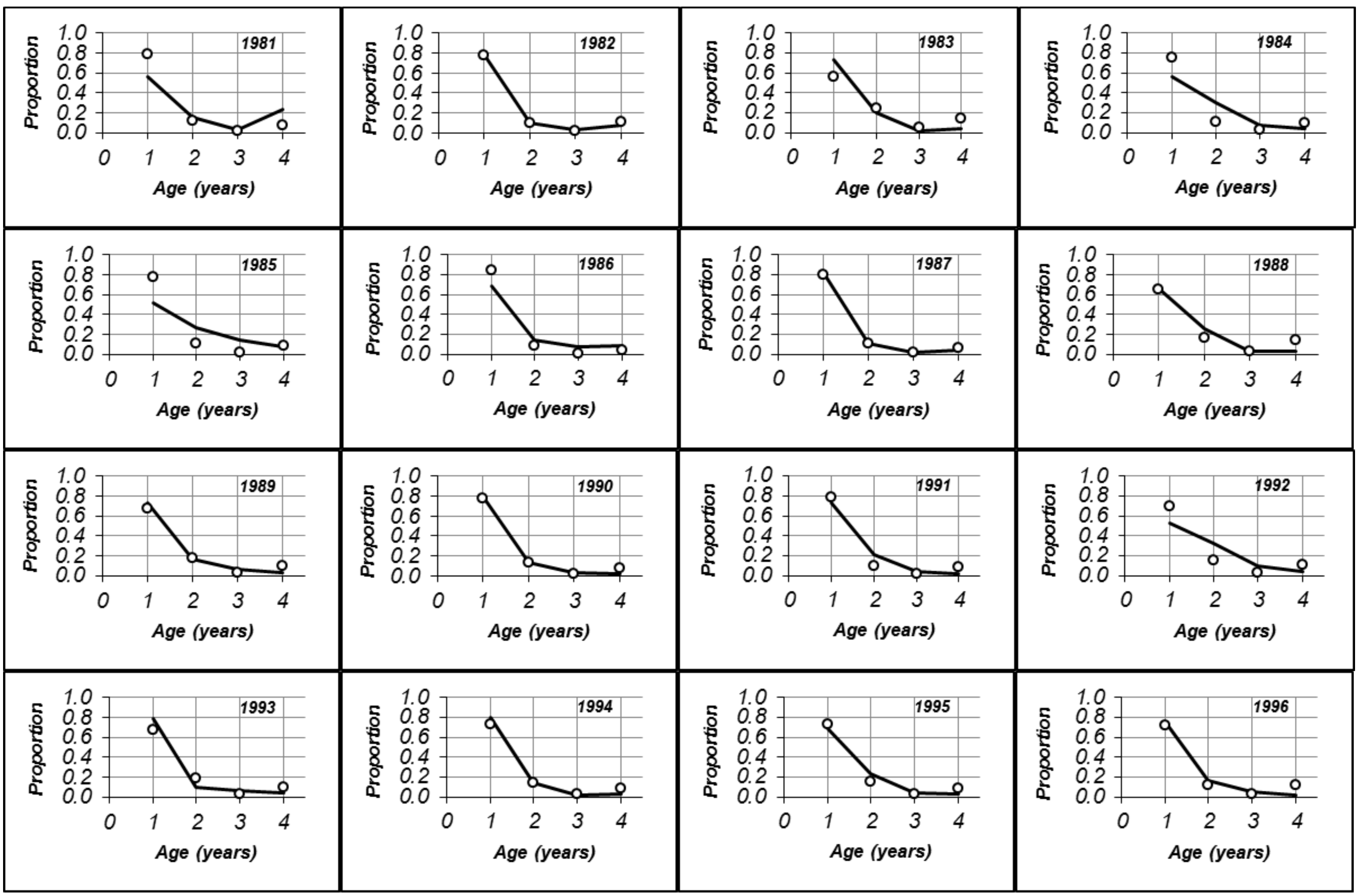


Figure 8 (continued):

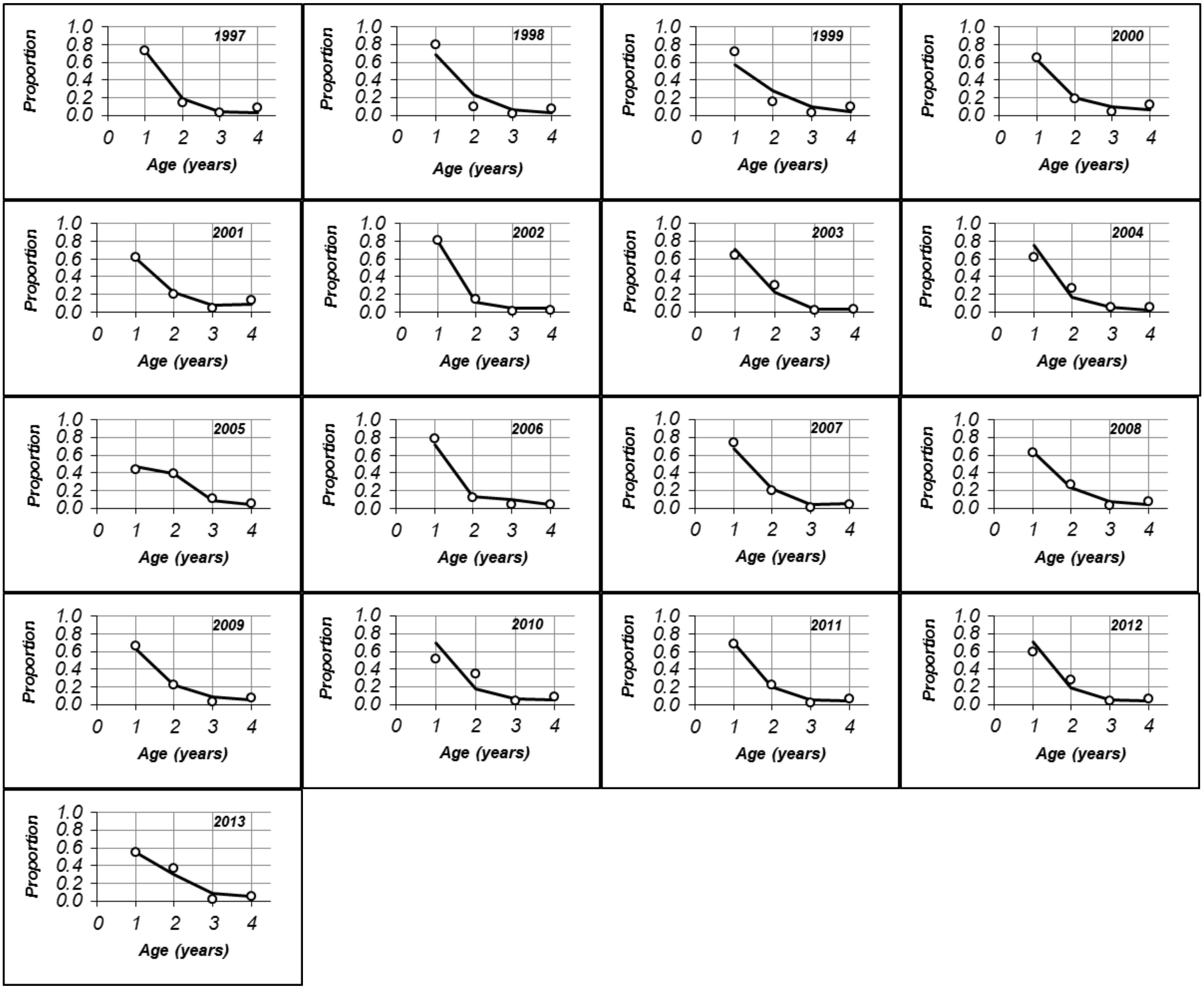


Figure 9: ASAP base model estimated commercial and recreational fleet selectivities (ages 1-4+).

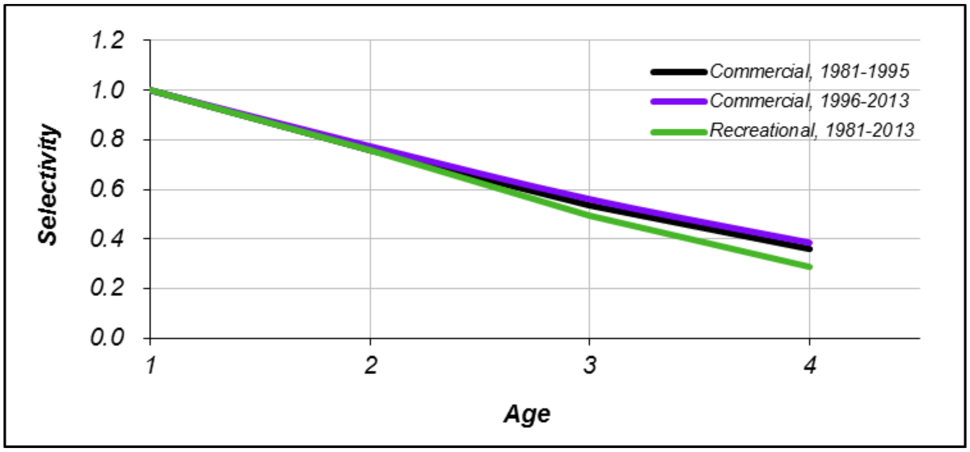


Figure 10: ASAP base model estimated female spawning stock biomass (MCMC median); dashed lines represent 95% MCMC derived confidence intervals.

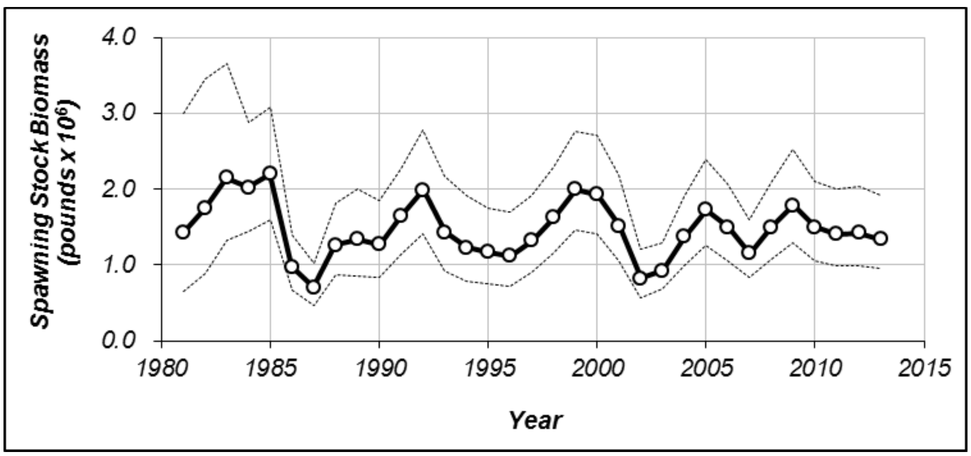


Figure 11: ASAP base model estimated recruitment. Dashed lines represent ± 1 asymptotic standard error.

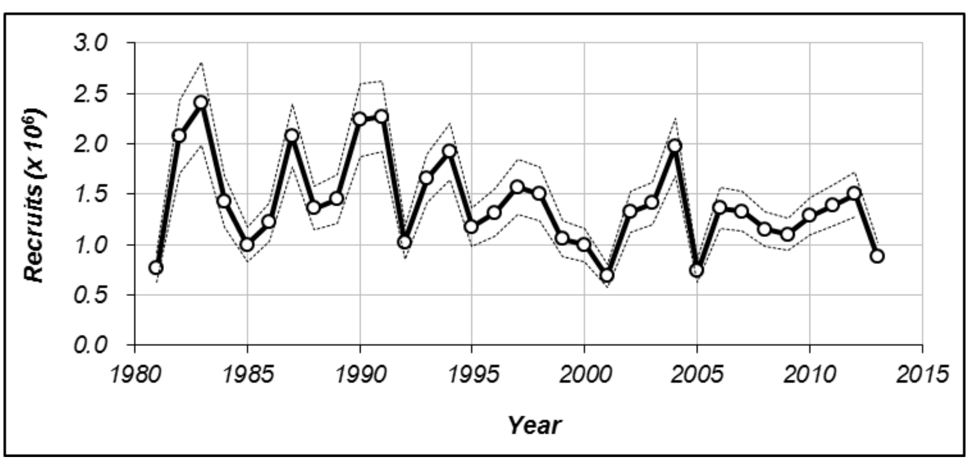


Figure 12: ASAP base model estimate average fishing mortality (MCMC median); dashed lines represent 95% MCMC derived confidence intervals.

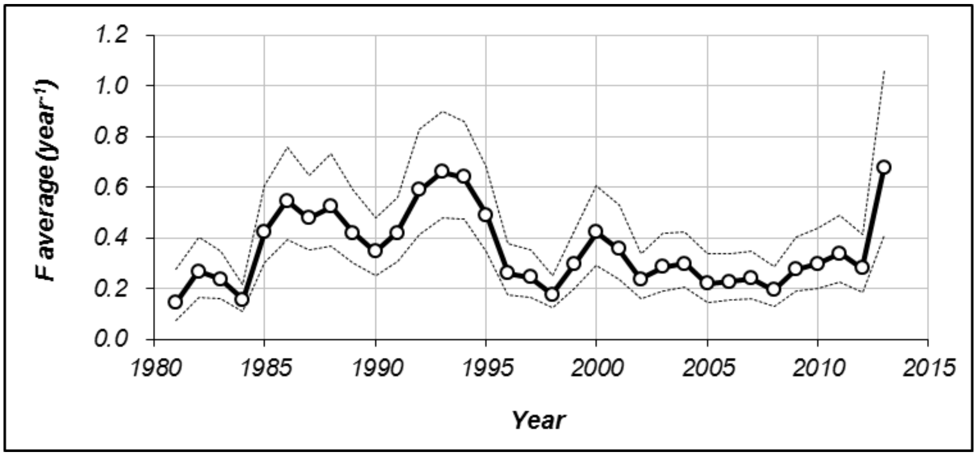


Figure 13: ASAP base model estimated age-1 recruits and spawning stock biomass. Arrows represent direction of the time-series. The yellow circle represents the most current data pair.

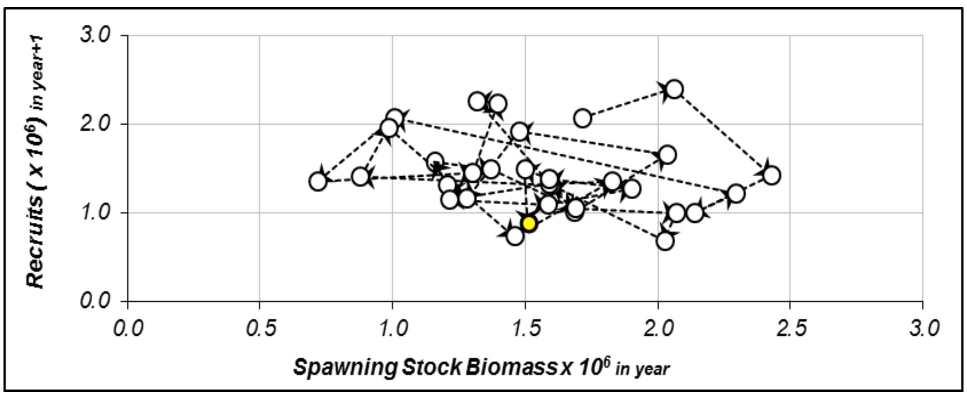


Figure 14: ASAP base model estimated age-1 recruits and female spawning stock biomass (open circles). Equilibrium recruitment is represented by the bold line. Equilibrium recruitment per spawning stock biomass corresponding with the minimum and maximum spawning stock biomass estimates are represented by the slopes of the dashed diagonals (min. spawning stock=26% SPR; max. spawning stock=80% SPR).

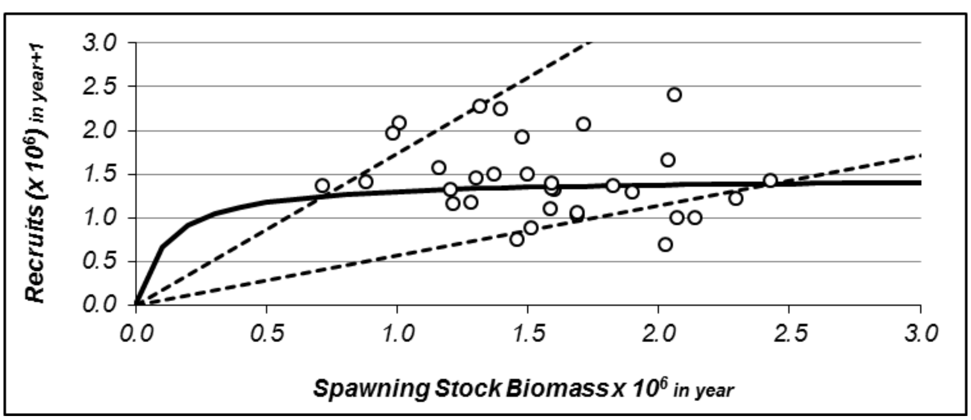


Figure 15: Retrospective analysis of ASAP base model for 2009-2013. Top graphics depict estimated ratios of annual average fishing mortality to $F_{30\%}$ (dashed line) and spawning stock biomass to $SSB_{30\%}$ (dashed line). Bottom graphic depicts estimated age-1 recruits.

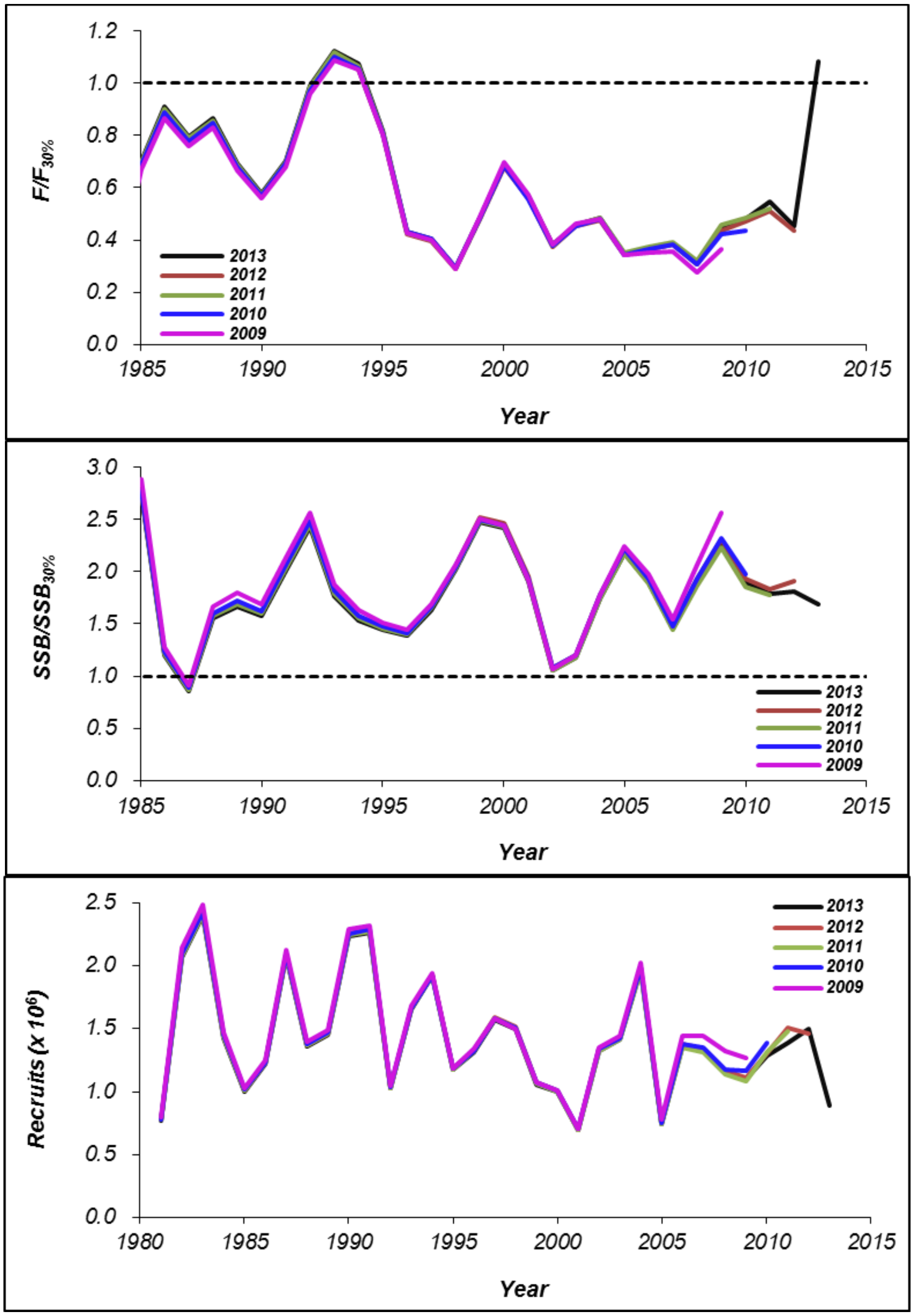


Figure 16: ASAP base model estimated ratios of annual average fishing mortality to $F_{30\%}$ and spawning stock biomass to $SSB_{30\%}$. In the top graph, arrows and dashed line represent direction of time-series. The yellow circle is the 2013 estimate and the red circle is current status (geometric mean of average F and female SSB 2011-2013). Bottom graphic depicts current status and results of 2000 MCMC simulations relative to limit reference points.